THE SURGEON'S HANDBOOK

BY

DR. FREDERICH VON ESMARCH

TRANSLATED FROM THE THIRD GERMAN EDITION

BY

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WITH SIX HUNDRED AND FORTY-SEVEN WOODCUTS

AN ENTIRELY NEW EDITION

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Inscribed to

Her Majesty

the

Empress of Germany

and

Queen of Prussia

AUGUSTA,

the

noble patroness of military surgery,

the

all-admired leader in the conflict of philanthropy against the horrors of war

with the deepest veneration by

the Author.

PREFACE TO THE FIRST EDITION.

On the occasion of the Exposition at Vienna, Her Majesty the Empress of Germany, in order to forward the interests of humanity under the symbol of the Red Cross, in time of peace as well as in war, condescended to offer two large prizes, one of which was to be awarded to the best **handbook of military surgery.**

According to the requirements, upon the exact fulfilment of which the award of the prize was made to depend, this handbook must „so completely represent the modern views of military surgery by an exact but brief description of the different dressings, and the various methods of applying them, as well as of the surgical operations which are performed in the field, that it would become the indispensable companion and practical assistant of every military surgeon".

The first prize was awarded to the author of this essay by the appointed jury, consisting of three members — Professor B. von Langenbeck of Berlin, Professor Billroth of Vienna, and Professor Socin of Bâle.

The author confined himself strictly to the requirements of the prize, and was influenced by the thought that a handbook of this kind should principally serve as an aid to the memory. This object can be better accomplished by pictures than by an abundance of words, for in the field there is not time to do much reading. A glance at a picture which plainly represents a dressing, an operation, or an anatomical preparation, will most quickly recall what had been previously learnt, but had escaped the memory in the pressure of military emergencies.

The book, therefore, contains many pictures, but as little text as possible.

While the surgeon, in time of peace, consults his anatomical handbooks and atlases before an important operation, to refresh his knowledge of the parts involved, in war-time he must generally relinquish this assistance with regret. Accordingly, the more important anatomical relations for all the major operations are illustrated by distinct drawings, partly taken from works with good copper plates, but for the most part prepared expressly for this essay.

In addition to this chief purpose, the author has kept in mind the following:

1. The book should be suitable for use in the instruction of those who are studying to become military surgeons, and also of the orderlies and nurses, for in war the surgeons are often so situated that they must educate their assistants themselves. The use of the illustrations will facilitate this task. For the same reason, particular attention has been given to the preparation of improvised dressings.

2. The book should be the guide of the organ of the sanitary aid societies in the preparation and preservation of dressing materials, apparatus, and instruments, as they are especially used in war. It would answer as an illustrated catalogue for the dépôts of the sanitary aid societies, and a reference to the pictures would spare the surgeon many words, when he desired materials for dressings from the dépôts.

3. The book should be useful to the surgeon who has to organize a hospital in any small place, in the preparation of apparatus for the treatment of the wounded — making his wishes clear to the artisans (carpenters, tinsmiths, etc.) by means of the illustrations.

PREFACE TO THE THIRD EDITION.

The first and the second (unaltered) edition of this work had already been exhausted, when, in 1881, the publisher unfortunately became bankrupt.

As I could not, for evident reasons, agree to the suggestion of the creditors' administrators of the estate, that the new edition should be published by their establishment, the book has not appeared until now, when, several difficulties having been overcome, it is issued in a very different form.

It is unnecessary to state that I have taken pains to make use of the extraordinary advances which surgery, and especially its technique, has made in recent years.

An index, which is as complete as possible, will greatly facilitate the search for names, articles, and illustrations.

I have moreover, omitted all the colored plates, which made the work unnecessarily expensive, and were besides not executed to my taste.

I have had woodcuts made instead, in which the colors are replaced by various methods of shading, and I hope that the object will be just as well attained by them.

In the illustrations of the different operations for applying ligatures to the arteries, the surrounding parts have been omitted, because they required so much space. A human figure with very strongly marked muscular outlines, has been inserted in place of them, and the position of the various incisions for the application of ligatures has been indicated upon it by numbers.

In the sketches of the operations themselves, the arteries are indicated by parallel strokes of shading, and the veins by cross-barred strokes, while the nerves are left white, so that these

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PART I.

RULES FOR DRESSING WOUNDS.

GENERAL RULES FOR THE TREATMENT OF WOUNDS AND INJURIES.

THE OBJECT OF THE TREATMENT OF WOUNDS.

The object of the treatment of wounds is the exclusion of all injurious influences which can interfere with healing. These injurious influences are:

1. Every **contamination** of the wound, for the **agents of decomposition** may thus gain admittance to the wound, and they are the cause of decomposition of the discharges of the wound, of inflammation, suppuration, wound fever, and all the accompanying complications of wounds.

This is to be avoided by extreme cleanliness (asepsis), the exclusion of the agents of decomposition (antisepsis), and their destruction (disinfection) if they have already contaminated the wound.

2. The **collection** and **retention** of blood and lymph (wound-discharge) in the wound, for these fluids separate the surfaces, and are themselves particularly liable to decomposition.

This can be prevented by **careful arrest of hemorrhage**, by providing **free escape** for the discharges of the wound, by **avoiding cavities** in the wound, and by **compression,** exercised by a good absorbent dressing — making the **wound** as **dry** as possible.

3. **Gaping** of the wound, because it hinders union by adhesion — by first intention.

This is avoided by timely and exact **union** of the edges and surfaces of the wound (suture of the wound).

4. Every **disturbance** of the wound (by movement, touching, mechanical injury, unnecessary examination, squeezing), for this inter-

feres with the healing process, and may cause hemorrhage and inflammation with their consequences.

This is avoided by abundant **covering** of the wound (protective dressing), careful **securing** of the dressing, and by **changing** the latter as **seldom** as possible (permanent dressing); and also by placing the injured part completely **at rest** (by bandages, cloths, splints, firm dressings, proper position, cradles, etc.), absolute rest in bed if the injury is severe, undisturbed quiet of the wound, avoidance of unnecessary examination, probing and squeezing. [1])

5. Every **hinderance to the return-circulation** of blood and lymph (congestion), for this may cause discharge to be effused into the wound from capillaries and lymphatics.

This may be prevented by **elevation** of the injured part, and by the **avoidance** of every **constriction** (strangulation), and the removal of constricting clothing or dressings.

6. The **entrance and settlement** of the **agents of decomposition** during the healing of the wound (septic infection).

This can be avoided by **antiseptic dressings** and by changing the dressing as seldom as possible **(permanent dressing)**.

7. **Inflammation** of the injured parts, with its consequences.

This is to be combatted by abstraction of heat, rest, elevation, elastic pressure; and, in inflammation of a joint, by separating the joint-surfaces by extension **(antiphlogosis)**.

CLEANLINESS (ASEPSIS).

Since the agents of decomposition (micro-organisms of putrefaction) are to be found everywhere, in the air as well as in the water, and attach themselves to every object, they must be removed, destroyed, or rendered harmless, before and during every operation, and before and during every dressing of a wound.

This is accomplished by scrupulous **cleansing** and **disinfection** of the wound and its surroundings, as well as of everything which can come in contact with the wound — air, hands, instruments, dressings.

CLEANLINESS OF THE SURGEON AND HIS ASSISTANTS.

Before touching any wound, before every operation, and before every dressing of a wound, the hands and forearms of the surgeon,

[1]) Absolute rest is the ideal treatment of wounds (Optimum remedium quies est — Celsus. To be let alone — Lister.) Although the ideal has not yet been quite attained by Lister's method (Cheyne, Antiseptic Surgery, p. 597), because the drainage-tubes and sutures have necessitated frequent change of the dressing, we nevertheless owe the immeasurable improvements in the modern treatment of wounds to the great surgeon, Joseph Lister, alone.

and of all his assistants (assisting surgeons, orderlies, nurses, students), must be very carefully cleansed with soap, brush, and nail-cleaner, and then washed in 1 to 20 carbolic acid solution, or 1 to 1000 bichloride of mercury solution. This cleansing must be repeated whenever, during the operation, the surgeon comes in contact with anything unclean — pus, feces, urine, etc.[1]).

Infectious material is apt to cling to dark woolen clothing, therefore it is advisable that not only the surgeon, but all his assistants should wear freshly washed **white linen coats** while they are at work in the hospital.

Sleeves and **aprons** of **rubber cloth** are also very useful, and these are to be thoroughly washed and disinfected with carbolic acid solution before every operation.

Fig. 1, for example, shows the dress which my assistants and myself wear at operations in the surgical clinic. To protect the feet from wetting by the very free use of water and antiseptic solutions, we wear Russian rubber boots over our shoes.

Fig. 1.

Operating-dress.

CLEANING THE INSTRUMENTS.

Every instrument which is used in operations or in dressing wounds must be cleaned and disinfected with the greatest care. Whenever they are used, they must be afterwards washed by an orderly or assistant trained in the antiseptic method, with hot water, soap, and a

[1]) I take this opportunity to emphasize the duty of every physician to attend to his teeth and mouth, and to keep them clean. I have only too often seen physicians greatly annoy their patients by the pestilent odor which came from their mouths, and some have lost patients from this cause. It is well enough known what masses of bacteria and vibriones may exist in the saliva of a neglected mouth. I need not argue further that no spray can be of any use, while such vapors pour upon the wound from the mouth of the operator.

brush, then dipped in a 3 % carbolic solution, and dried with a clean linen cloth. They should be kept in a place where they will be safely protected from handling by meddling persons, and from contact with the atmosphere. Before an operation, all the instruments are to be laid in a clean flat glass or china dish (Fig. 2) filled with 3 % car-

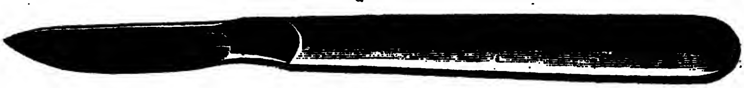
Fig. 2.

Glass tray for instruments.

bolic solution. But the knives must not be left in the solution too long, for the edge will soon be attacked by the carbolic acid. It is therefore better to lay them in a smaller dish filled with alcohol.

The instruments should be made as plain as may be, and, in particular, with as few grooves and fissures as possible, for dirt is apt

Fig. 3.



Aseptic knife.

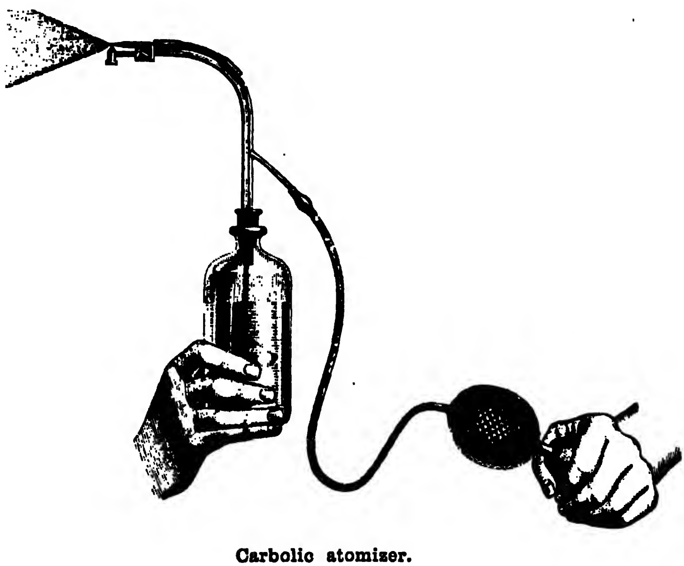
to lodge in them. The knives, etc. made of one piece of steel (aseptic) are preferable to those furnished with wooden or ivory handles (Fig. 3).

PURIFYING THE AIR (SPRAY).

As the atmosphere always contains the agents of decomposition, and especially in old, badly ventilated, and over-crowded hospitals, Lister considered it necessary to disinfect the air during operations, and whenever a dressing was renewed.

This is accomplished by a spray of some disinfecting fluid (a 3 % carbolic solution, hydrogen peroxide, etc.), produced by an

Fig. 4.



Carbolic atomizer.

atomizer (Richardson's spray-producer, Fig. 4), and directed upon the wound and the hands of the operator.

If for any cause, the spray had to be discontinued for some time, Lister endeavored to protect the wound from contact with the atmosphere during this interval, by covering it with a compress of gauze wet with carbolic solution (the „guard").

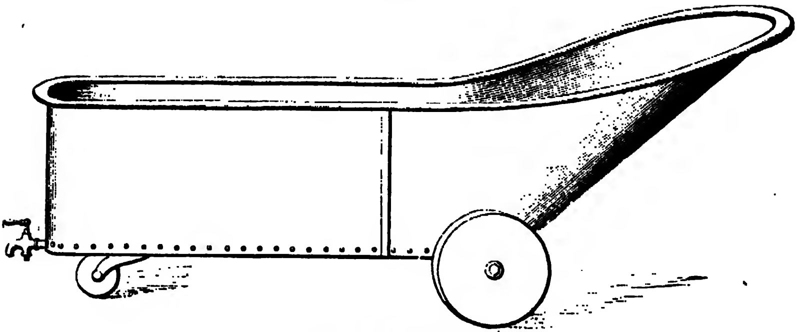
But long experience of practical surgeons has shown that perfect results can be obtained in operations without the use of the carbolic spray, so this inconvenient accessory may be dispensed with in military surgical practice. [1])

[1]) In my clinic, the carbolic spray has not been used during an operation for a long time. I now use our very complete apparatus, operated by a compressing air-pump (see Neuber, Anleitung zur Technik der antiseptischen Wundbehandlung, p. 9), only for disinfecting the atmosphere of the operating room before operations.

CLEANSING THE PATIENTS.

Before every operation, and before every dressing of a fresh wound, the entire body of the patient should, if possible, be thoroughly washed in a **bath-tub** with soap and a brush.

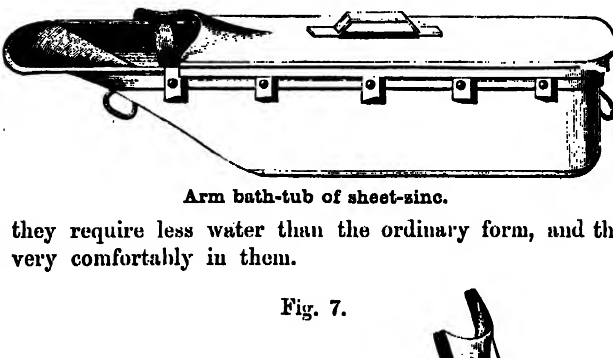
Fig. 5.



Quincke's bath-tub.

The **bath-tubs** invented by Quincke, with a very oblique side for the back (Fig. 5), are exceptionally well fitted for use in war,

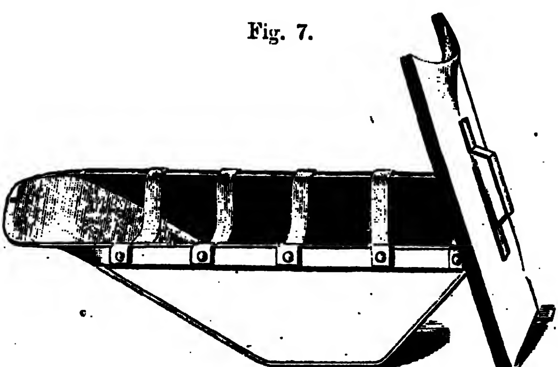
Fig. 6.



Arm bath-tub of sheet-zinc.

because they require less water than the ordinary form, and the patient reclines very comfortably in them.

Fig. 7.



Leg bath-tub of sheet-zinc.

For cleansing injured extremities, **arm-** and **leg-baths** of sheet zinc, having a cover with an opening at one end (Figs. 6 and 7), are employed.

There are knobs on both sides, to which strips of bandage can be attached, upon which the injured limb may be suspended.

Large bath-tubs can be made after the same pattern, suitable for the treatment of burns, wounds of the back, bed-sores, etc.

Immediately before the operation, the entire field of operation, the entire neighborhood of the wound, is again thoroughly cleansed and disinfected.

In the first place, since the agents of decomposition cling especially to the hair, all hair near the wound must be shaved off — and on the scalp for a distance of at least $1\frac{1}{2}$ inches from the edges of the wound.

Then the neighborhood of the wound is rubbed with a piece of cotton dipped in ether or spirits of turpentine, in order to dissolve and remove the oily matter of the skin. Next follows a thorough washing with soap and a brush; and, finally, the disinfection with carbolic, or bichloride solution. The whole field of operation may be painted, in addition, with a solution of iodoform in ether — 1 to 7.

Before operations on the **hand** or **foot**, the thick upper layers of epidermis should be removed, as far as possible, by stiff brushes and files, after having been softened by soap-baths, and especial care must be taken to remove the dirt under the nails and between the toes.

Before operations about and within the **mouth**, the teeth must be very carefully cleansed with a tooth-brush and soap, tartar and decayed teeth removed, and the mouth repeatedly washed out with acetate of alumina.

Before operations in the neighborhood of the **anus** and **genitals**, the intestine must be thoroughly emptied several days beforehand, if possible, by laxatives, enemata, and irrigation.

If there are crusts, scabs, ulcers, or septic granulations in the wound, or in the field of operation, they must first be thoroughly scraped away with the sharp spoon, and their site then disinfected with an 8 % solution of chloride of zinc.

If these proceedings are painful, they are not to be undertaken until chloroform-anaesthesia has been begun.

The **operating-table**, upon which the patient lies during the application of a dressing, or during the operation, must be perfectly clean, and should therefore be scrupulously cleansed from blood, pus, etc., and disinfected after every operation. Rubber cloths are very useful to spread over the cushions of the operating-table, having been always thoroughly washed, and disinfected with carbolic solution, before they are used.

It is best to have the patient laid upon the operating-table **naked**, and then wrapped in a large **rubber cloth**, which has an opening at the proper place through which the part to be operated upon can be exposed.

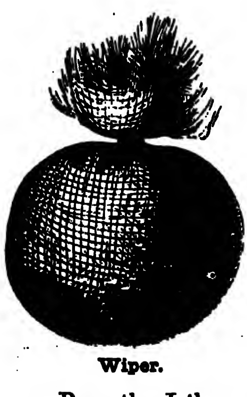
Fig. 8.

Protecting cloth.

(The use of the protecting cloth for operations upon the lower extremity will serve for an example, as in Fig. 8.)

CLEASING THE WOUND.

Fig. 9.



Wiper.

For wiping away blood during an operation, **sponges** and **wipers**, dipped in 3 % carbolic solution, or in 1 to 5000 bichloride solution, are employed.

Wipers (German, Tupfer; artificial sponges) are loose balls of absorbent cotton, wood-fibre, jute, or some similar substance, wrapped in aseptic gauze (Fig. 9).

As the cotton collects into a firm mass when the fluid is squeezed out, and no longer readily absorbs, it is advisable to put a layer of sterilized cocoa-nut fibre between the inner and outer layers of cotton (Sampson Gamgee), which will, by its elasticity, prevent this massing of the cotton.

Recently I have had wipers made of wood-fibre, wrapped in gauze, and then sterilized, and I find that they are far more useful than the cotton wipers.

The wipers are to be destroyed after having been used once [1]).

Sponges should never be employed for wiping away the blood during an operation unless all the dirt contained in them has been removed with the greatest care, or rendered harmless.

To clean bath-sponges thoroughly, they must first be beaten between cloths, while dry, with a wooden mallet, until all the sand has been removed. They are then repeatedly washed in lukewarm clean water which has been boiled — hot water makes them shrink. They are next soaked in a cold solution of permanganate of potash, 1 to 1000, for 24 hours, and the solution must be renewed in 12 hours. After they have been again washed out in boiled lukewarm water, they are put into a 1 % solution of hyposulphite of soda, to which is added one fifth as much of an 8 % solution of concentrated hydrochloric acid in water. They are well stirred about in this with a wooden stick, until they have lost their brown color. If they are left too long in this solution, they become soft, and tear easily. They are next washed in clear water until they are entirely odorless.

For 25 large sponges, about 5000 grams (175 fl. oz.) of the hypo-sulphite of soda solution, and 1000 grams (35 fl. oz.) of the hydro-chloric acid solution will be required.

In order to destroy the dry spores (which are by no means rendered harmless by the manipulations just described), after they have begun to grow, the sponges are laid in lukewarm water and kept for 3 to 5 days in a warm place (95° to 100° F.). The water being changed daily. The same object can be attained by sterilization, if a sterilizing-oven is available.

Not until then are the sponges put in 1 to 20 carbolic acid, or 1 to 1000 bichloride solution, and this must be renewed in two days. They remain in this until they are needed. The solution must be renewed every fortnight, and the sponges must have been in the solution for at least one week before they are used for an operation.

During the operation, the sponges must be washed out in clean water, when they are bloody, before they are put back in the carbolic or bichloride solution; they are then handed to the operator from the solution, after having been squeezed out dry.

Sponges which have been used in aseptic operations must be repeatedly washed with soap and washing soda to free them from clotted blood and fat, and then kept in 1 to 20 carbolic solution for a week before they are used for another operation.

Sponges which have been used in infectious, decomposing, or gangrenous wounds should be burned at once.

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[1]) In time of war, the preparation of wipers, under strict medical supervision, would be a thankworthy employment for the ladies — instead of the previously customary preparation of lint.

To clean the neighborhood of wounds, and to wipe away pus on the renewal of a dressing, sponges should never be employed — only „wipers".

THE IRRIGATOR.

For cleansing and disinfecting wounds and their surroundings by irrigation, the **irrigator, or wound-douche** (Fig. 10) is employed — a vessel of tin or glass (Fig. 12), to the lower outlet of which is fastened a rubber tube with a nozzle, by which a stream of disinfecting fluid can be conducted to the wound [1]).

The strength of the stream is regulated by the pressure of two of the fingers which hold the tube, and by elevation or depression of the vessel. The nozzle is to be put into the vessel when the irrigator is not in use (Fig. 11), and the nozzle should be of pewter or glass, and heavy enough to keep the end of the tube in the vessel. A stopcock is unnecessary.

It is dangerous to irrigate the crevices of the wound under strong pressure, for by so doing the fluid may be driven into the cellular tissue. For the same reason, the use of a syringe for washing out wounds is to be condemned, for with this instrument the pressure of the stream can not be controlled [2]).

According to Thiersch, an irrigator can be improvised by knocking out the bottom of a wine-bottle, sticking a rubber tube through a hole in the cork, and hanging up the inverted bottle by a string (Fig. 13).

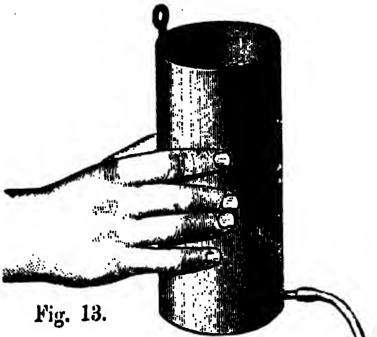
PUS-BASINS.

Variously shaped **pus-basins** of sheet-metal, hard rubber, or glass, serve to receive the water and pus — their edges fitting closely to the different surfaces of the body (Figs. 14 and 15).

[1]) Sterilized water, or boro-salicylic acid solution (1 to 6 to 500) is employed for irrigation during the operation; at the end of it, before the sutures are inserted, bichloride solution, 1 to 5000.

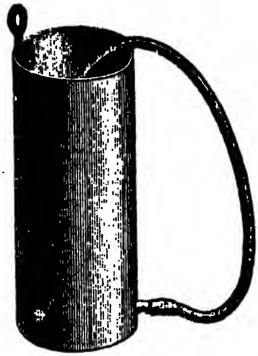
[2]) I invented the wound-douche in 1858, to take the place of the dangerous wound-syringe which had been in common use up to that time (see Deutsche Klinik, 185*, No. 25).

Fig. 10.



Irrigator in use.

Fig. 11.

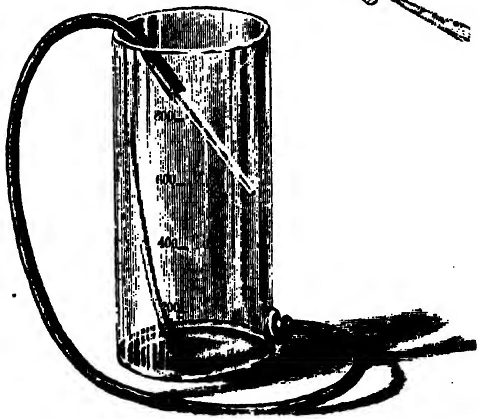


Irrigator closed.

Fig. 13.

Improvised irrigator.

Fig. 12.



Glass irrigator.

In changing the pus-basins, the empty basin is to be placed under the full one, so as not to conceal the latter from sight, and not to spill its contents.

Fig. 14.

Kidney-shaped pus-basin of hard rubber, sheet-metal, or glass.

Fig. 15.

Pus-basin of sheet-metal or glass, for use in cleansing an entire extremity.

The contents of the full basin must be poured at once into a slop-jar.

ARREST OF HEMORRHAGE.

Before the wound is closed and dressed, the **hemorrhage** must be scrupulously **arrested.**

This is best done by seizing **all** the wounded vessels — arteries and veins, with clamp-forceps, and by tying them firmly and securely with antiseptic catgut (Lister's catgut). The **reef-** or **square-knot** is to be used in tying ligatures (see Fig. 24); not the **granny-knot** (see Fig. 25), for the latter is apt to slip. The ends of the threads are cut off about $^1/_8$ inch from the knot.

In operations performed with artificial ischaemia (Esmarch's bloodless method) such as amputations, resections, etc., it is not easy to find all the wounded vessels, as they do not bleed.

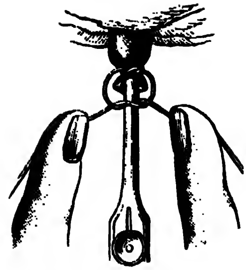
In such cases, diagrams of sections of the limbs, in which the exact position of the most important arteries, veins, and nerves is indi-

cated, will be found useful aids to the memory for consultation before the operation.

Great readiness in finding even the smaller vessels can be attained by practice. The muscular branches of medium size are usually the most difficult to find, because they retract into the bellies of the muscles, and these arteries are the most frequent source of secondary hemorrhage.

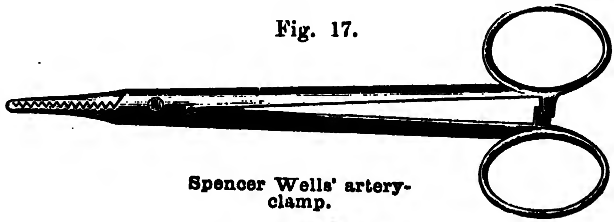
These branches can generally be found in the middle of the transverse section of the belly of the muscle, where the coarser layers

Fig. 16.



Ligature of a vessel, forceps hanging.

Fig. 17.



Spencer Wells' artery-clamp.

Fig. 18.

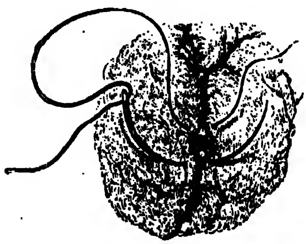
Amputation-stump with artery-clamps.

of cellular tissue between the muscular fibres meet together, forming a star-shaped figure.

In amputations, after the bone has been sawed off, as many wounded vessels are to be seized with **clamp-forceps**, or **Spencer Wells's artery clamps** (Figs. 16 and 17) as the supply of these instruments will admit, and they are allowed to hang while the vessels are ligated — beginning with the uppermost (Fig. 18). The rest of the vessels are then to be sought out and seized with the forceps thus set free.

If a bleeding vessel cannot be well isolated and drawn forward as is necessary for ligature, it may be secured by **suture**. A strongly curved needle is made to carry a suture through the tissues which surround the bleeding point, and the thread is then tied so as to include a small portion of these tissues, together with the bleeding vessel (Fig. 19).

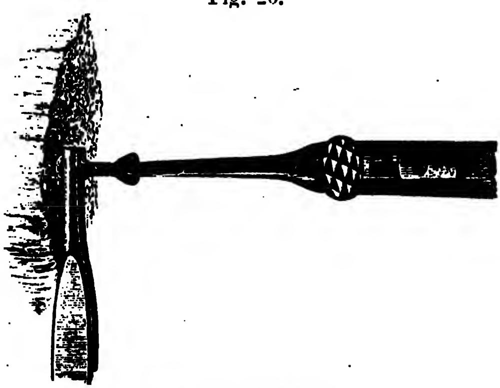
Fig. 19.



Artery occluded by suture.

If antiseptic ligatures are not at hand, the arteries can also be closed by **torsion**. The vessel to be secured is seized with a clamp-forceps, drawn out a little, and twisted on its axis six or eight times, according to its size, the central end of the exposed piece being held by the fingers, or, preferably, by another pair of forceps (Amussat's forceps) (Fig. 20).

Fig. 20.



Torsion of an artery.

By this procedure, the internal coat of the artery is torn across and rolled up within itself, so that it securely closes the vessel like a valve.

In prolonged and difficult operations in regions of the body in which the bloodless method cannot be employed, it is well to isolate all vessels — arteries and veins, as soon as they are recognized, by pushing a probe or forceps under them, so that they can be secured by two clamp-forceps. The vessel is then to be cut between the forceps, and each end tied separately.

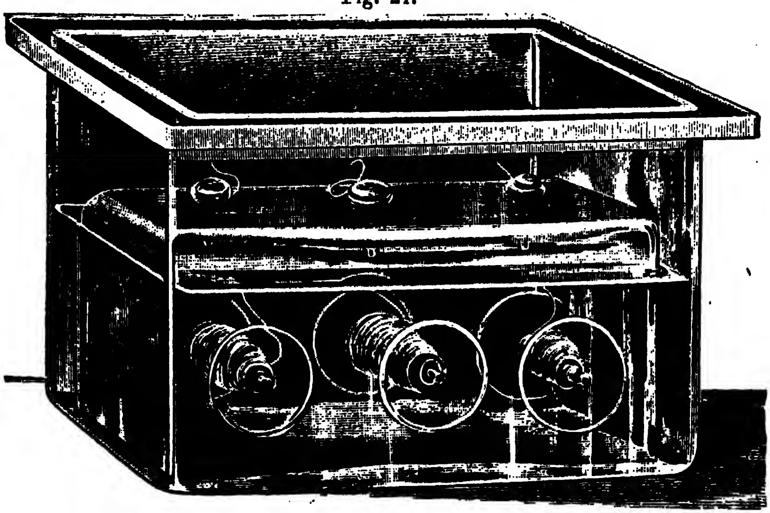
CATGUT.

Antiseptic catgut (Lister's catgut), which is used for the ligature of vessels, and the suture of wounds, has the property of dissolving in the wound, and of becoming completely absorbed, after it has fulfilled its purpose.

The simplest and most efficient method of making catgut antiseptic, is the following:

The ordinary commercial catgut (No. 1 to 3) is vigorously cleaned with a brush in soft soap and water, and, after washing in pure water, is wound on glass spools and laid in bichloride solution, 1 to 1000, for 12 hours: then in an alcoholic 1 to 200 solution of bichloride for 12 hours: and it is then preserved dry in tightly closed glass vessels.

Fig. 21.



Glass catgut-box.

Just before it is used, it is laid in a vessel filled with an alcoholic 1 to 2000 solution of bichloride — for example in the **glass catgut-boxes** (Fig. 21), suggested by Hagedorn, in which stands

another smaller box containing three glass spools upon which is wound catgut of three different sizes. A ball and socket valve prevents the ends of the thread from slipping back into the inner box[1]).

The catgut first proposed by Lister, prepared with carbolized oil, is not reliably antiseptic, and hence is probably not in use anywhere at present.

On the other hand, the **chromic acid catgut**, afterwards suggested by Lister, is very hard, and resists absorption for a longer time than the sublimate catgut, hence it is to be preferred for certain operations — in ligature of the pedicle in ovariotomy, for example.

To prepare the catgut in this way, it is put in 10 $^0/_0$ carbolized glycerine for 48 hours, and then in a $^1/_2$ $^0/_0$ aqueous chromic acid solution for 5 hours.

The **juniper-catgut** of Kocher is also very hard, and reliably antiseptic. The catgut is put in oil of juniper for 24 hours, and then kept in alcohol.

CZERNY'S SILK.

In some operations it is advisable to employ an antiseptic material for ligature which will not be absorbed, but encapsuled. Raw Chinese silk is suitable for this purpose, made antiseptic according to Czerny's directions — boiled for 10 minutes in carbolic acid solution, 1 to 20, and preserved for use in a 2 $^0/_0$ solution. Unfortunately, it cannot be entirely relied upon to remain encapsuled permanently. The ligatures are not infrequently thrown out by suppuration after a longer or shorter interval.

UNITING THE EDGES OF THE WOUND.

The practice of uniting the edges of the wound with **sticking-plaster**, which was formerly common, should be rejected, because it hermetically closes the wound, irritates and inflames the skin, and contradicts the principles which lie at the foundation of antisepsis.

A surgeon who brings together a fresh wound with sticking-plaster, without observing antiseptic precautions, is in danger of legal prosecution (v. Nussbaum).

Very small and superficial wounds can be closed with **English sticking-plaster**, or with strips of **gauze and collodion**, after they have been disinfected with an antiseptic solution.

[1]) These boxes can be obtained from v. Poncet, Glashüttenwerke, Berlin.

Superficial wounds of the skin, which are unsuitable for suture because, for instance, the edges are contused, can be drawn together by strips of starched gauze bandage, wet with carbolic acid solution, in such a way as not to cause retention of the discharge of the wound.

In some cases (for example, in wounds of the scalp) it is advisable to use a bandage which has been rolled at both ends (double-headed roller bandage — Fig. 22), and thus to press the edges of the wound together from both sides.

But the best method for fresh, clean (aseptic) wounds, is to unite the edges by suture.

Fig. 22.

Double-headed roller.

SUTURE.

Sutures are inserted with straight or variously curved **needles**, and only with **material for sutures** which is completely aseptic — catgut, Czerny's silk, silver wire, iron wire, horse-hair, silkworm-gut, etc.

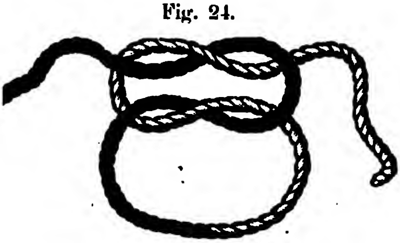
The **interrupted suture** (Fig. 23) is the form most frequently used, and is decidedly the best when it is important to secure very accurate adaptation of the edges of the wound, as in plastic operations.

Fig. 23.

Interrupted suture.

It is necessary to tie the suture in a reliable double knot, so that it will not slip. Accordingly the **square-**, or **reef-knot** (Fig. 24) is employed, in which both ends of the thread pass in the same direction through each loop; while in the **granny-knot** (Fig. 25), which is apt to slip, the ends of the thread pass through the loops in opposite directions.

Fig. 24.



Square-knot.

Fig. 25.

Granny-knot.

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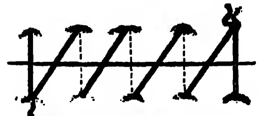
If there is much tension of the edges of the wound, it is well to give the threads a double turn in the first knot (the **surgeon's-knot**, Fig. 26), and then to finish the knot like the square-knot.

Fig. 26.

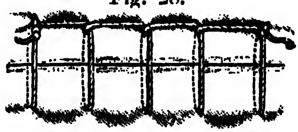
Surgeon's knot.

Fig. 27.



Continuous suture.

Fig. 28.



Glover's suture.

The **continuous** or **glover's suture** (Fig. 27), which can be applied much more quickly than the interrupted suture, has recently come into common use again.

A modification of this suture which is very frequently useful, is shown in Fig. 28, in which the needle is passed under the loop of the previous stitch every time before the thread is drawn tight.

In wounds with such great loss of substance that it is not possible to bring the edges together with sutures (skin and scalp wounds), primary union may nevertheless be obtained by immediate **transplantation** of large pieces of skin from the arm of the patient, or from the freshly amputated limb of another, or from the body of one who has just died.

In transplantation, flaps of skin, two inches square and larger, are cut, and all the subcutaneous adipose tissue is carefully removed by scissors curved on the flat, so that the piece of skin looks like white glove-leather on both sides. The wound is then covered with one or more such pieces, which are secured to its edges by catgut sutures, and an antiseptic dressing applied over them.

In this way I have at once completely covered the large wound on the forehead left after a rhinoplastic operation with two large flaps from the arm, and secured union by first intention.

DRAINAGE AND DEEP SUTURES.

Before the wound is closed, care is to be taken that no fluids can remain in the bottom of the wound.

To **conduct** these **from** the wound, we employ **drainage**.

DRAINAGE.

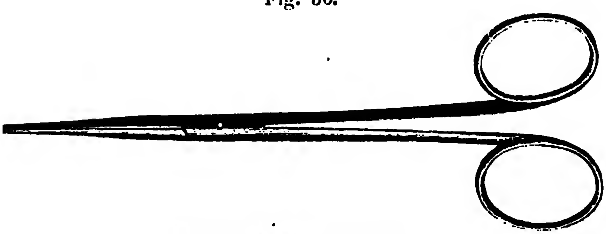
When much suppuration is to be feared — in septic wounds, abscesses, resection of the hip, etc., it is advisable to place **rubber tubes**, perforated on their sides by holes (Fig. 29), in the dependent parts of the wound, in order to drain the cavities which exist in it — as first recommended by Chassaignac.

Fig. 29.

Rubber drainage-tube.

Lister uses a peculiar dressing-forceps with long slender arms (Fig. 30) for introducing drainage-tubes into deep wounds.

Fig. 30.



Lister's drainage-tube forceps.

It is not a bad idea to sprinkle the drainage-tubes with jodoform before inserting them (König).

In fresh and clean (aseptic) wounds, the use of rubber drainage-tubes is disadvantageous, because they irritate the wound, acting as foreign bodies; because they permit the entrance of the agents of decomposition into its interior; and because they always necessitate an early renewal of the dressing, and thus cause a disturbance of the wound. To avoid the last-mentioned draw back, the use of softened (decalcified) bone-tubes (Neuber, Fig. 31) is to be preferred, for they dissolve in the wound and are absorbed, like catgut, as soon as they have fulfilled their purpose.

These tubes are turned out of the bones of cattle, put in a 33 % solution of hydrochloric acid for about 12 hours, to decalcify them, and preserved in an alcoholic solution of bichloride of mercury, 1 to 5000.

In case of need, bundles of catgut strands (Chiene), or of disinfected horse-hair, or braids of glass-wool (Schede) can be employed for drainage.

Fig. 31.

Bone drainage-tube.

In most fresh and aseptic operation-wounds, however, drainage is unnecessary, if care is taken:

1. That no closed cavities remain in the bottom of the wound, in which blood or serum can collect;

2. That the wound in the skin is not entirely and hermetically closed — so that any discharge which may form within the wound can easily make its way to the surface.

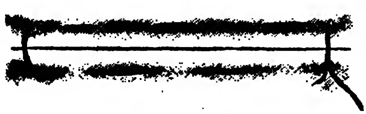
3. That the wound is covered with a dressing which will exert equable pressure upon every part of it, which will readily absorb the escaping discharge, and which will favor the drying up of the latter by evaporation.

DEEP SUTURES.

Cavities in the deeper parts of the wound are best avoided by deep sutures which press the deeper parts of the surfaces of the wound together; they are the following:

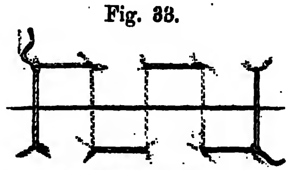
The **fold-suture** (Fig. 32), which is most useful for uniting very thin and loose edges of skin — for example, in the eyelids, as it raises the skin in a fold so that broader surfaces are brought into contact.

Fig. 32.



Fold-suture.

Fig. 33.

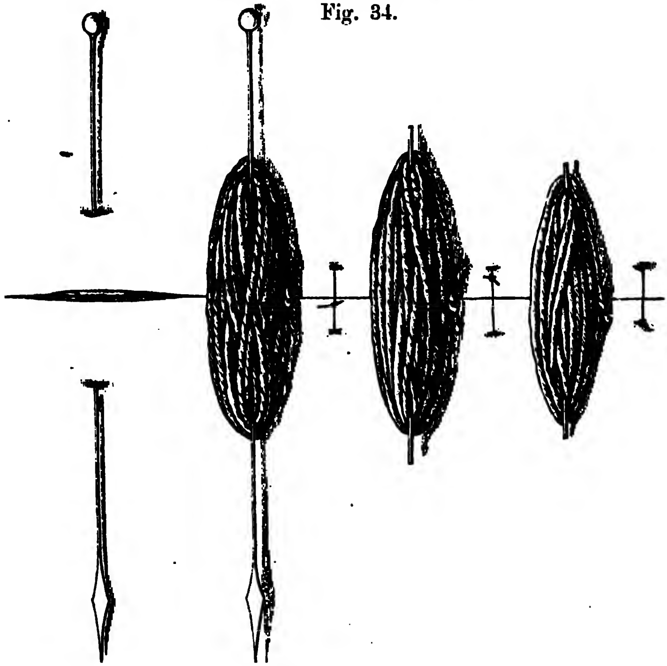


Mattress-suture.

The **mattress-suture** (Fig. 33) is the same, except that the needle is carried much deeper, in order to press together the surfaces at the bottom of the wound.

The **twisted or hare-lip suture** (Fig. 34) is made with pins (entomological, or Carlsbad pins), the points of which have been hammered and ground flat. The pins are inserted through the skin at a little distance from the wound, and cotton threads which have been soaked in bichloride solution, are twisted around them in alternate

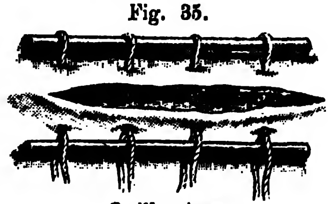
Fig. 34.



Twisted suture.

circular and figure-of-eight turns, so as to press the edges of the wound together. The ends of the pins are then cut off with wire-cutting pliers. Some fine interrupted sutures can be inserted in the intervals between the pins, to gain more accurate adaptation of the edges of the wound. The pins can be withdrawn with a forceps, by twisting movements, on the second day, but the bunches of threads, which are usually adherent to the skin by crusts of blood, are to be left some days longer. This suture is particularly well adapted to unite the widely gaping wounds of the skin which occur in plastic operations on the face.

Fig. 35.

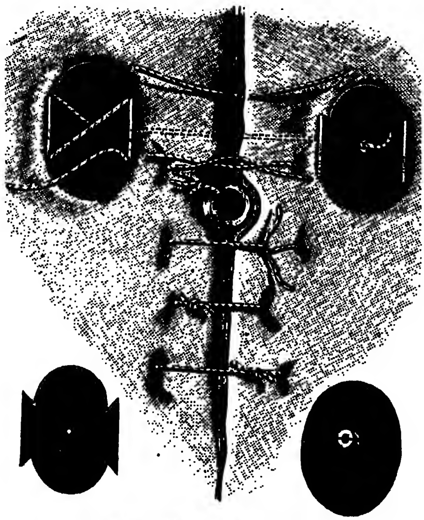


Quill suture.

The **quill suture** (Fig. 35) presses the deeper parts of the wound together by cylindrical rods (quills, pieces of a catheter), drawn together by silver wire or Czerny's Silk.

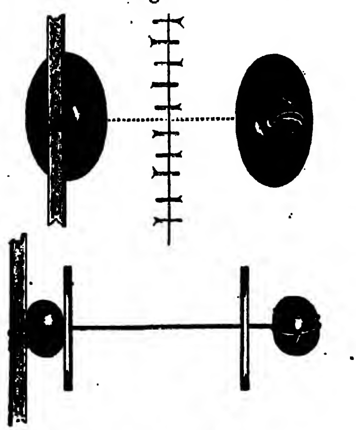
The **lead plate suture** (Lister) (Fig. 36) is made with silver wire, passing through lead plates with a hole in the center, and twisted around their up-turned edges, in figure-of-eight turns.

Fig. 36.



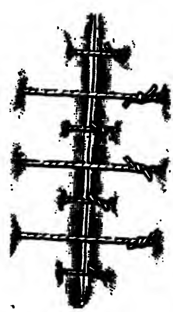
Lister's leadplate suture.

Fig. 37.



Bead suture.

Fig. 38.



Combined sutures.

The **bead suture** (Thiersch) (Fig. 37) is made by passing the silver wire through the lead plates, and then through glass beads, and securing it by twisting it around a small piece of wood — such as a match.

The superficial and deep interrupted suture can be combined, if there is tension, when it is important to relieve the superficial sutures of pressure until the first adhesion has occurred in the wound — relaxing sutures (Fig. 38).

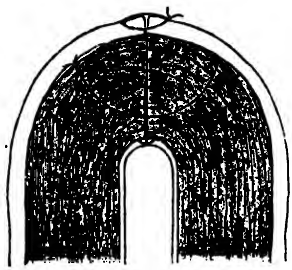
In the same way, the continous suture may be combined with the mattress suture, and so on.

But when it is important to press together the deeper parts of the wound so that every cavity will be surely obliterated, it is best to employ the **sunken**, or **buried catgut suture** (Fig. 40) — that is, the deeper parts of the surfaces of the wound are sewed together by continuous or interrupted sutures of catgut. before the ordinary superficial sutures are inserted, the threads are cut off close to the knots, and the sutures left to be absorbed like the ligatures applied to vessels[1]). The action of the lead-plate and deep sutures upon the deeper parts, is shown in the schematic sections of amputation stumps, in Figs. 39 and 40.

Fig. 39.

Lead-plate suture, schematic.

Fig. 40.



Buried sutures, schematic.

But as it is never possible to be entirely certain that there will be no discharge anywhere in the bottom of the wound when these deep sutures are employed, the wound in the skin is left open a little at its most dependent part (according to the law of gravity), or small openings in the skin **(buttonholes)** are made with the knife at suitable places, parallel with the direction of the wound in the skin, so that the tension of the superficial sutures will cause them to remain open (Fig. 41).

It is well to cut away (with scissors curved on the flat) some of the fat from the inner part of these openings in the skin, so that

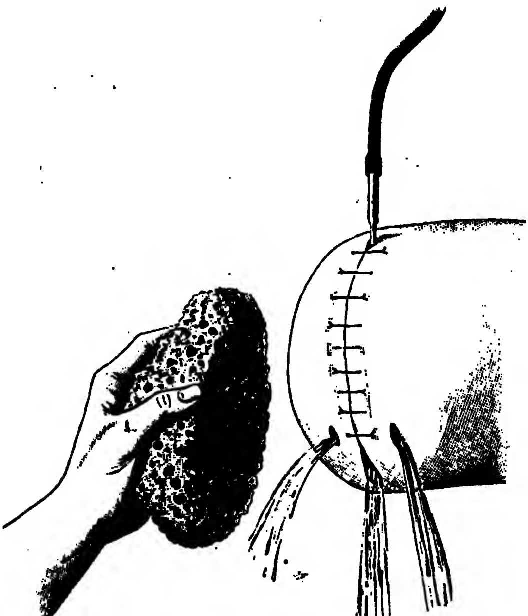
[1]) The surgeons of the large Hôpital Saint-André in Bordeaux, have obtained brilliant results in major operations (amputations, etc.), since 1869, by the combination of deep compressing sutures (quill, lead-plate sutures) with incomplete superficial sutures, even without following the antiseptic method. (Azam, „Réunion primitive et pansement des grandes plaies." Bordeaux, 1879.).

it cannot block up the holes from within. The edges may also be everted a little by a catgut suture.

The small openings rapidly heal up after they have served their purpose.

Finally the wound must be fully covered with a dressing, which will be sufficiently soft and elastic to equably press together the whole region of the wound. In this way the oozing of blood, and the discharge of lymph can be prevented, or lessened. The dressing must also readily and quickly **absorb** the discharge which takes place (crumpled gauze, sponges, cushions of peat, moss, sawdust, etc.) and favor the **drying up** of the discharges, by evaporation of their watery constituents. Hence air- and water-proof materials (protective silk, mackintosh, varnished paper) are not to be employed. The elastic bandages which are applied over the dressing to increase the compression at first, must be removed after some hours.

Fig. 41.



Button-holes. Final irrigation.

Before the dressing is applied, the closed wound must be once more irrigated with antiseptic fluid until the latter returns clear from all the openings (Fig. 41).

The wound is then to be firmly squeezed together with a large sponge or wiper, until all the fluids which have been left in it are

pressed out, and this pressure must be maintained until the sponge is replaced by the first part of the dressing (cushions, or crumpled gauze) which must also be very firmly applied.

DRESSINGS.

The dressing of a wound has the following objects to accomplish:

1. It should protect the wound from all external injurious influences, and from the entrance of the agents of decomposition in particular. It must therefore fully cover the whole region of the wound, fit closely on every side, especially shutting it at the edges **(occlusive dressing, protective dressing).**

2. It should readily absorb the discharges of the wound — blood, serum, pus; and readily allow them to dry (**dry dressing, dry treatment**).

3. It should prevent the decomposition of the discharges (**antiseptic dressing,** Lister).

There are a great number of materials which more or less completely fulfill these purposes, and a still larger number of (antiseptic) substances which have the property of preventing or stopping decomposition in the discharge of wounds.

MATERIALS FOR DRESSINGS.

The materials to be employed for dressings:

1. Must be perfectly clean — aseptic;

2. Must be soft and elastic, so as to fit closely to the surface of the body under moderate pressure;

3. Must readily absorb every sort of fluid — possess great absorbent powers;

4. Must not be air-tight, so that the absorbed fluids may evaporate quickly, and be readily oxidized by the oxygen of the atmosphere.

5. Must contain substances which will render the agents of decomposition harmless — antiseptics.

In **military practice** the most suitable **materials** for **dressings** are the following:

1. **Gauze** (Mull, surgical gauze), a loose cotton cloth, made absorbent by having its oily matters removed by boiling in soda, is employed:

a. in several layers, as a **Lister occlusive dressing;**

b. in pieces very loosely folded together, as **Volkmann's crumpled gauze;**

c. made into **bags** of different sizes — sewed with aseptic cotton thread, which are filled with other dressing-materials (peat, moss, sawdust, wood-wool, etc.) and serve as **cushion-, or padded-dressings;**

d. cut into **bandages,** 2 to 5 inches in width, which serve to secure the occlusive dressings, after being dipped in antiseptic fluid — carbolic or bichloride solutions.

For this last purpose, the **starched** gauze (crinoline) is particularly well-fitted, because the turns of the bandage when applied wet, stick together, and prevent the dressing from slipping.

2. **Cotton.**

a. Cotton, made **absorbent** by removal of its fatty impurities (Bruns), quickly absorbs water, and is therefore especially fitted for cleaning soiled parts of the body, when used as balls or wipers, and used only once; also for the padding of particular parts (the axilla); but it is not at all suitable for laying directly upon the wound, as the surface in contact with the discharge packs together into a hard impenetrable layer.

b. The **ordinary cotton,** not absorbent, is used for padding splints; and especially in the form of **cotton batting bandages,** 4 to 6 inches wide, for stuffing and closing the edges of the dressing, for it is well known that cotton is the best filter for straining out the infectious materials floating in the atmosphere.

3. **Peat,** coarsely powdered in the form of peat-dust (Neuber). The light brown variety („Moostorf") absorbs very well (nine times its weight of water), if it is slightly moistened beforehand; the **black peat** is less absorbent, but has antiseptic properties because it contains humic acid. It is, moreover, much cheaper in regions where there are peat bogs.

4. **Peat-moss** (sphagnum), which can be obtained cheap in any forest or marsh region, can be easily made aseptic by drying and sterilization, is very compressible, absorbs very well, and is cleaner than peat.

5. **Wood-sawdust, wood-wool,** and **wood-fibre,** are good dressing-materials, because they are all very compressible, absorb well and quickly, are easily rendered aseptic by sterilization, or by pouring boiling water over them, and are not expensive.

Sawdust (Porter) can be obtained everywhere, and is already at hand in large quantity when wooden barracks are built. Poplar sawdust is the most absorbent. Pinewood sawdust has also antiseptic properties.

Wood-wool and **wood-fibre** are prepared in various manufactories at a low cost. The latter is particularly suitable for filling wipers, to be used in operations instead of sponges, as well as for padding splints.

6. **Forest-wool, oakum,** and **jute,** are inferior to the others, for they are not so soft and absorbent, but in case of need they are always useful as dressings.

The last mentioned materials (Nos. 3 to 6) are all best used for dressings in the form of **cushions**, or **stuffed bags** — a bag of gauze being partially filled with the material — so that it can easily be shaken about in it **(cushion dressings)**.

For use in different parts of the body, various shapes and sizes of cushions are used — in some of them, slits must be made in certain places, to allow them to fit more closely to the desired part [1]).

Fig. 42.

Cushion for dressing.

Fig. 42 shows a gauze cushion of this sort, suitable for an amputation of the thigh.

Since it is inconvenient to have a very great variety of sizes and shapes, only the dimensions of the most useful will be given here.

The cushion for the largest dressings (chest, abdomen, thigh, groin) should be 28 inches long, 20 inches broad, and from $^3/_4$ to $1^1/_4$ inches thick, and should have a slit 4 to 8 inches deep, its edges being sewed up before the cushion is filled, situated in the middle of the long or the short side — according to the wound or operation.

For smaller dressings, cushions 2, 4, 8, to 16 inches square are employed.

Cushions 20 inches long, and 6 inches broad are suitable for padding splints.

Before applying these cushions, the contents are to be arranged by shaking so that they will fit all the depressions in the neighborhood exerting equable pressure upon the entire wound, and so that the greatest quantity will lie at the most dependent part — for example, at the back, in dressing wounds of the chest and axillary regions.

By folding over the corners, as in dressing amputation stumps, the surgeon should attempt to completely occlude the wound.

A gauze bandage wet with carbolic acid or bichloride solution, is then applied so as to bind the cushion firmly and smoothly to the surface of the part.

[1]) In time of war the preparation of these bags and filled cushions under medical supervision, would form a thankworthy task for patriotic women.

The edges of the dressing are then covered with cotton-batting bandages, so that the entrance of air to the wound will be prevented; and, finally, additional turns of gauze bandage are carried near the edge of the cotton, but so as not to touch the skin anywhere, the cotton projecting from under them upon every side (see Fig. 43).

All cavities and depressions (the axilla, for instance) are carefully filled with salicylated cotton, or crumpled gauze, before the turns of bandage are carried over them.

When an operation has been performed by Esmarch's bloodless method, an elastic bandage of thin rubber is applied in addition over the entire dressing, to increase the pressure during the first two or three hours; and in operations in the neighborhood of the anus a bandage of this kind is applied at the edges of the dressing, to prevent the entrance of the contents of the bowel.

IMPERMEABLE MATERIALS.

Impermeable materials are now seldom used in dressing wounds since it has been recognized that they do more harm than good — by preventing the evaporation of the discharges of the wound.

Under this head are to be classed: —

Lister's oiled silk protective, which is laid directly over the wound, to shield it from the irritating qualities of the carbolic acid, etc. If the material of the dressing possesses sufficient absorbent power, it is unnecessary — as is also the **glass-wool** recommended by Schede.

Should it be desired to use anything of this sort, the far cheaper **varnished-paper**[1]) is to be preferred. This may also replace the expensive **mackintosh**, which was laid between the seventh and eighth layers of gauze in the original Lister dressing, in order to prevent any discharge which might penetrate the dressing from directly reaching the surface.

This varnished-paper is also excellent to cover and retain the moisture of wet applications (Preissnitz's compresses, cataplasms): and parchment paper, oil-silk, and rubber-tissue can also be employed for this purpose.

Heavy waterproof materials, such as cotton cloth filled with oil-varnish, or rubber-cloth (for example, Billroth's batiste, oiled cloth, etc.) are used to protect the bed-linen when renewing dressings, in permanent irrigation, etc.

[1]) Tissue-paper is painted with a large brush with linseed varnish, to which 3 % siccative („drier“) or varnish-extract has been added. The sheets are then hung up on strings in an airy room for 48 hours, until they are perfectly dry. To make the paper antiseptic, 1% of thymol is added to the varnish.

Pure sheet rubber, made of raw brown rubber, is excellent for covering the operation-table, and protecting the rest of the patient's body in operations, and when the dressings are renewed (see Fig. 8); and for making the aprons and sleeves for the surgeon and his assistants (see Fig. 1).

From the same material are cut the rubber bandages, 2 to 3 inches wide, which are used:

1. For bandaging the limbs in employing Esmarch's bloodless method.

2. For applying outside of the entire dressing of the wound after operations performed upon the extremities with this method, in order to increase the compression for the first two hours, until the danger of secondary oozing of blood has passed.

Fig. 43.

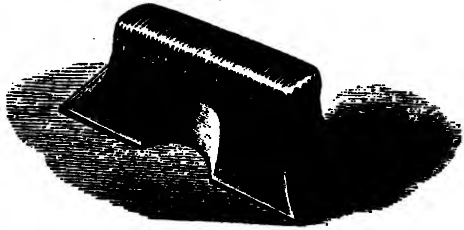
Elastic bandage with Lister dressing.

3. For applying along the edges of the dressing, in order to prevent the entrance of air (by the respiratory movements of the chest or abdomen, for instance), or of the contents of the bowel when the dressing lies near the anus (Fig. 43, after Lister).

THE POSITION OF THE PATIENT.

The position of the patient is of great importance in applying or changing the dressings. He must be so placed that the part to which the dressing is to be applied is accessible on every side, and the body must be maintained in a natural position during the entire dressing of the wound.

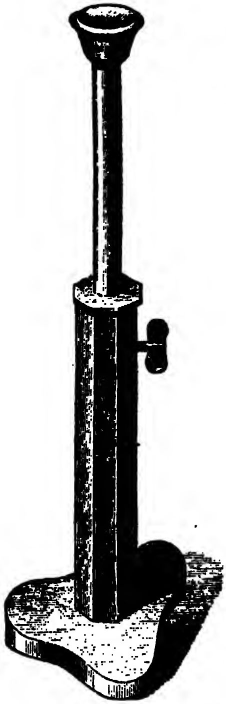
Fig. 44.



Pelvic support (Volkmann).

To support the body, the operating table will answer in part, but the **padded pelvic support** described by Volkmann (Fig. 44),

Fig. 45.



Heel-rest (Esmarch).

which should have a height of 8 inches for adults, will also be necessary, and in some cases two of these will be needed. The assistants or orderlies hold the body in the chosen position with their hands. In making some dressings, mi **heel-rest** (Fig. 45) will also be found useful.

The figures 46 to 50 show: (See pag. 31 and 32.)

1. The position of the patient in applying dressings to the upper part of the body (Fig. 46).

2. The position in applying dressings in the neighborhood of the pelvis, anteriorly (Fig. 47).

3. The position in applying dressings in the neighborhood of the pelvis, posteriorly (Fig. 48).

4. The position in applying dressings to the abdomen (Fig. 49).

5. The position in applying dressings to the lower extremity (Fig. 50).

ANTISEPTICS.

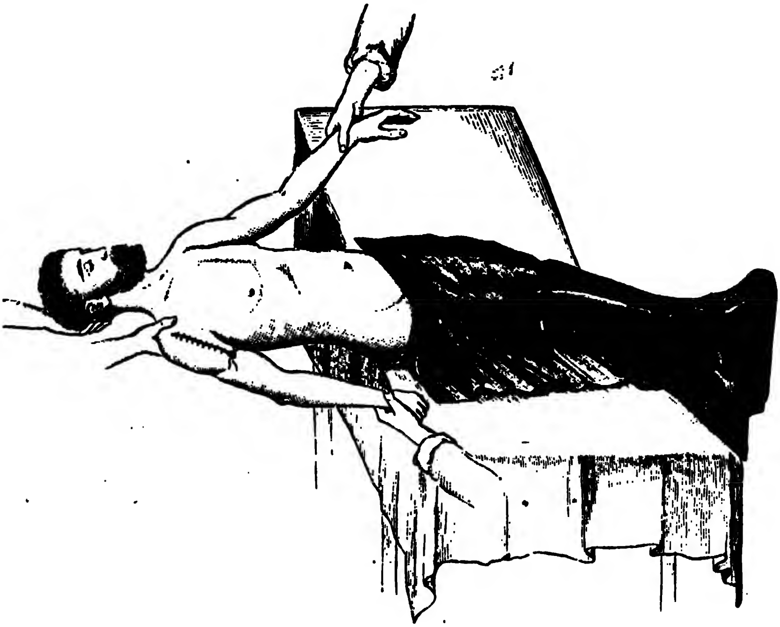
STERILIZATION.

The surest way of rendering the materials to be employed for dressings **aseptic**, to destroy the agents of putrefaction which are in them, is **sterilization** by dry heat and steam.

The air in a **sterilizing oven** of good size is slowly heated to a temperature of 90 ° C. (194 ° F.), while the material lies spread out in it on wire-grating.

After the dry heat has acted upon it for a quarter of an hour, hot steam is allowed to enter the oven until the temperature reaches 100 ° C. (212 ° F.). This temperature is maintained for half an hour, then the steam is allowed to escape, and is replaced by dry hot air, which is allowed to cool off gradually after half an hour, the moisture being thus made to evaporate from the material. Materials made aseptic in this way, must be at once wrapped in parchment or varnished-paper, and kept in boxes of sheet-metal or glass until they are used, or until they are impregnated with antiseptics.

Fig. 46.



Water can be sufficiently sterilized for use in operations, to cleanse the wound, by long-continued boiling.

But as plain water irritates the tissues, making them swell up, it is necessary, to make it resemble blood-serum by adding ordinary table-salt in the proportion of 6 to 1000.

Sea-water, drawn up from some distance below the surface of the sea, can also be employed for this purpose, after it has been

Fig. 47.

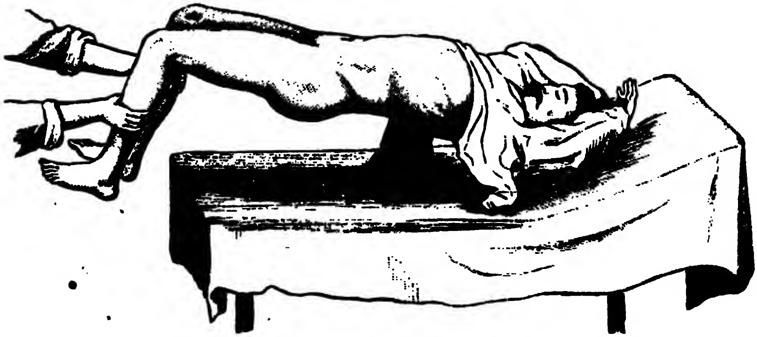


Fig. 48.

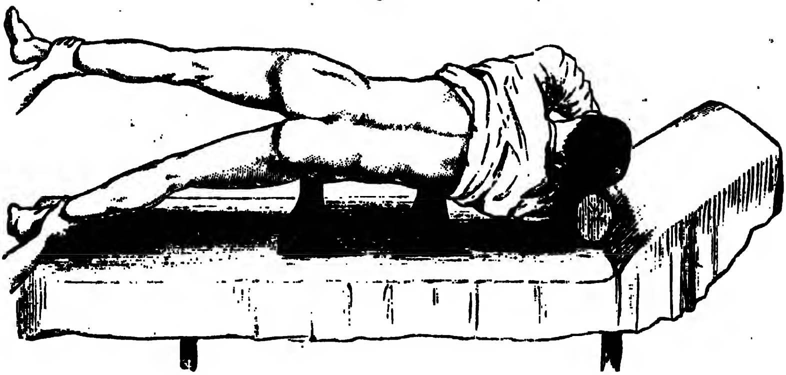


Fig. 49.

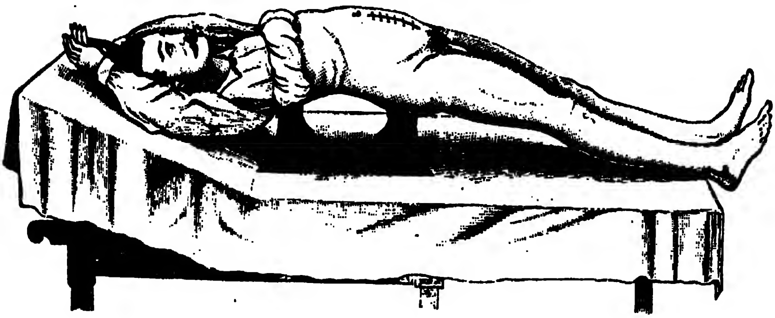


Fig. 50.

boiled and has had its proportion of salt reduced to that given above, by the addition of boiling fresh water.

Among the large number of substances which prevent putrefaction, now used in the antiseptic treatment of wounds, the most important for military surgical practice are the following:

1. CARBOLIC ACID (Lister).

This is a very powerful antiseptic. A watery solution of 1 to 1000 will hinder the development of bacteria by continuous action, although the action of the concentrated solution (1 to 20) for 24 hours is necessary to entirely prevent their growth.

According to Koch, solutions in oil and alcohol have no antiseptic action.

Carbolic acid is, however, poisonous — and not by internal use alone. It is also quickly absorbed by wounds, and even by the skin, especially in children; and in weak, thin blooded adults, as well, and in those who suffer from disease of the kidneys, it not infrequently causes severe symptoms of poisoning — both acute (collapse) and chronic (disturbances of digestion, vomiting, marasmus.)

It is also irritating to the skin, especially when employed in a moist form, and causes erythema and eczema, often with febrile symptoms; and strong solutions irritate the surfaces of wounds and cause an increase of the discharge — and even suppuration (antiseptic suppuration — Lister).

Recently, therefore, it has been used much less than formerly, when by Lister's recommendation it dominated the entire antiseptic method.

It is used:

a. In weak carbolic solution (3 %) to disinfect the hands, the instruments, the skin in the neighborhood of the wound, the wound itself, the sponges, and the atmosphere (carbolic-spray).

b. In strong solution (1 to 20) to disinfect septic wounds.

c. For the impregnation of the materials used for dressings — especially gauze (Lister gauze, carbolized gauze).

Since carbolic acid is very volatile, and the quantity of it in the impregnated materials diminishes very rapidly by evaporation, it is advisable to prepare the latter only just before they are to be used.

In time of war, the best method for its preparation is that of Bruns: —

To 400 grams of powdered colophony is added in succession 100 grams each of alcohol and carbolic acid, and 80 grams of castor oil — or 100 grams of melted stearine. The mixture is stirred until it is reduced to a smooth brittle mass about the consistency of an extract, and is immediately placed in an air-tight vessel for preservation. When desired for use, the mixture is dissolved in 2 liters of alcohol, with constant stirring. To impregnate the gauze, the mixture is poured out over 1 kilogram gauze, which is spread out roughly

in a flat pan, and readily absorbs it. In order to secure an even distribution, the gauze must be wrung out two or three times from one end to the other (3 to 5 minutes are to be spent in doing this) or passed through a wringing machine. The material is then hung up to dry — but for as short a time as possible, until the alcohol has for the most part evaporated — about five minutes out-of-doors in the summer, and from ten to fifteen minutes in a moderately heated room in winter. The gauze is then to be kept in closed boxes of sheet-metal.

2. BICHLORIDE OF MERCURY (Koch).

This is the strongest of all the disinfecting substances in use. According to Koch, a solution of 1 to 20,000 in water will kill the spores of the anthrax-bacillus, and a solution of even 1 to 300,000 in water will prevent their development.

The bichloride is odorless, but very poisonous, if used in strong solution, or in a weak solution for a long time.

In addition to great irritation of the skin (eczema, chapping) it may cause symptoms of systemic poisoning (stomatitis, salivation, severe diarrhoea with tenesmus, ulcerative inflammation of the rectum and colon, nephritis, etc.) so that the greatest prudence is necessary in using the stronger solutions.

As the bichloride is at once decomposed by contact with metal, it cannot be used for the disinfection of instruments, nor kept in metal vessels. The irrigators for use with bichloride solutions must therefore be made of glass, and the basins of glass, china or paper.

It is employed:

a. In weak aqueous solution, 1 to 5000, to disinfect the hands and the neighborhood of the wound, to wet the wipers and sponges, and to irrigate the wound before applying the sutures.

b. In strong aqueous solution, 1 to 1000, for thorough irrigation of septic wounds, and for this purpose it is far more reliable and less dangerous than the 1 to 20 carbolic solution.

c. In alcoholic solution, 1 to 1000, to preserve catgut, silk, sponges and drainage tubes.

d. To impregnate gauze and other materials for dressings. A solution of 1 part bichloride, and 100 parts table-salt, in 40 parts glycerine and 1000 parts water, is poured over the materials, the superfluous fluid squeezed out with the hands or a wringing machine, and the material dried by moderate heat.

As aqueous solutions, and the materials impregnated with them, sometimes irritate the skin, and as the bichloride after some time evaporates from them (Lazarski), Lister has proposed to mix the bichloride with the serum of the blood of horses (1 to 100) and to impregnate

the gauze with this (bichloride-serum gauze). In this way it is deprived of its irritating properties, but not of its antiseptic power.

3. CHLORIDE OF ZINC (Lister).

This is a tolerably strong antiseptic, does not attack uninjured epidermis, but is caustic to other tissues. It is odorless, not poisonous, and not expensive. It is used:

a. In strong (8 %) aqueous solution (Lister) for the thorough disinfection of septic tissues, when suppuration with decomposition is present, etc.

b. In concentrated solution (with water in equal parts) with which cotton tampons are wet, as an a excellent caustic in hospital-gangrene (König).

c. In weak solution (1 to 2000) for antiseptic compresses, and for impregnating materials for antiseptic dressings (jute gauze).

d. In chloride of zinc pads (Bardeleben) which form a very cheap antiseptic dressing.

100 grams chloride of zinc is dissolved in $1^1/_4$ liters hot water, and 1000 grams jute is worked in it until all the solution has been absorbed. The jute is then spread out and dried in the air or in an oven.

4. IODOFORM (v. Mosetig).

Iodoform is not a very strong antiseptic, as it does not protect against erysipelas, but its action is lasting, for it is but slightly soluble, and not very volatile. It does not irritate the wound, in fact it diminishes pain, and the quantity of the discharge; the disagreeable odor of iodoform can be improved by the addition of tonka-bean.

On the other hand, the use of the drug is not without danger; there are persons, especially old people, and those afflicted with disease of the kidneys or of the heart, in whom the severest symptoms of poisoning (disturbances of digestion, vomiting, brain-symptoms, mania, melancholia), often with fatal results, apear after the use of small quantities. On this account very large amounts should not be employed.

Iodoform is used:

a. As a powder for sprinkling over fresh wounds, in which union by first intention can not be expected — gunshot wounds, for example; and also wounds in the neighborhood of the various natural openings of the body (mouth, anus, vagina) where infection can not be avoided.

b. In solution in ether (1 to 7), for washing parts where an operation is to be performed — leaving a finely divided yellow deposit upon the skin, when the ether has evaporated.

c. In iodoform gauze, to place over fresh sutured wounds in a single layer under the other dressings; and to tampòn wounds of the mucous cavities (mouth, nose, pharynx, rectum, vagina, bladder, urethra) which are to be kept open, and in which complete antisepsis is impossible.

Iodoform gauze is made by sprinkling 100 grams (3 oz) of iodoform over 10 meters (11 yards) of gauze in a clean basin, and rubbing up the latter with clean hands until it is of a uniform yellow color.

For use in mucous cavities, the sticky iodoform gauze of Billroth is best, because it adheres closely to the surfaces of the wound and will prevent decomposition for weeks. It is prepared by drawing 6 meters of gauze through a solution of 100 grams of colophony in 50 grams of glycerine and 1200 grams of alcohol (95 %), and rubbing 230 grams of iodoform into it, after it has dried.

Iodoform gauze, suitable for any purpose can be prepared very rapidly by pouring iodoform ether (1 to 7) upon gauze, and rubbing it until the ether has evaporated. This method is of course more expensive than those previously described.

5. BORIC ACID (Lister).

Boric acid is a moderately strong antiseptic, which irritates the tissues very little, if at all, and it has, moreover, no poisonous properties. [1])

It is employed:

a. In aqueous solution (35 %) instead of carbolic acid, for operations upon the abdominal cavity, the rectum, etc; and also, for the same purpose, with the addition of salicylic acid as suggested by Thiersch (2 parts salicylic acid, 12 boric acid, 1000 water).

b. As borated lint (Lister), very useful for covering small wounds, especially in the face, made by dipping lint in a solution of 1 part boric acid in 3 of boiling water; borated cotton and borated gauze are prepared in the same way.

c. Boric acid ointment (Lister) for covering sutured wounds to which a large antiseptic dressing can not be applied — in plastic operations on the face, for example; and for covering granulating wounds.

Lister's boric ointment is prepared of: —

Acidi borici pulv., cerae albae, aa. 5 grams, ol. amygd. dulc., paraffini, aa. 10 grams. Simpler and more durable, and therefore better, is a mixture of 20 parts boric acid with 100 parts vaseline or glycerine ointment.

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[1]) But it is said that it is not altogether safe to use large quantities with children. — (Rupprecht.)

6. ACETATE OF ALUMINA (Burow).

Acetate of alumina is a very powerful antiseptic, for a solution of 25 parts to 1000 will not only prevent the development of bacteria, but will destroy their power of reproduction after it has acted for 24 hours (Pinner). It quickly corrects the foul odor in the discharge of wounds, and in the secretions of the skin; it is not poisonous, and not expensive, but it can only be employed in a fluid form, because the acetic acid evaporates in drying, leaving only the inert hydrate of alumina. As it attacks the instruments, and makes the hands rough, it is not suitable for use in operations, although it diminishes the hemorrhage by its strong astringent action on the capillaries, and it is therefore not a bad idea to wet the wipers with it.

It is employed in an aqueous solution, 1 to 5 %, in which gauze compresses are dipped for use as moist applications; and also in purifying baths for suppurating, gangrenous, or foul wounds and ulcers, and for eczema and foul-smelling secretions of the skin (axilla, anus, scrotum); and it is the best of all antiseptics for **permanent irrigation** of gangrenous abscesses, decomposition, and gangrene of the tissues.

A 1 % solution is made by mixing 24 grams of alum, and 38 grams of sugar of lead, with 1 Liter of water, allowing it to stand for 24 hours and then filtering.

7. SALICYLIC ACID (Thiersch).

Salicylic acid is a strong antiseptic, irritates the wound but little, and is not poisonous. But it is apt to separate from the dressing-materials in the form of dust, which causes coughing and sneezing. It is also not cheap.

It is used in salicylic solution (1 part to 300 water) for irrigating wounds; and, with boric acid, for antiseptic irrigation; and it acts very well in cases of eczema due to carbolic acid or bichloride of mercury, when used as an emulsion (1 part to 5 of water) or as salicylic acid ointment (10 % with vaseline, or glycerine ointment).

In the form of salicylated cotton (3 % and 10 %), freshly made, it was formerly much employed; but it is not to be recommended for use in the field, for the salicylic acid falls out of the cotton while it is being transported.

8. PERMANGANATE OF POTASH.

Permanganate of potash is very soluble, not expensive, not poisonous, and it is quite a strong antiseptic, for it kills spores even in a 5 ‰ solution, and entirely corrects the foul odor of decomposing wounds after irrigation for a short time. But its action is of short duration, for it is at once decomposed by the discharge of wounds, and

forms a slimy brown deposit with it, which soon begins to emit a foul odor.

It is used in aqueous solution (1 to 1000, up to 100), the color of red wine and darker, according to the amount of decomposition to be corrected (Condy's fluid).

9. THYMOL (Ranke).

Thymol is a good antiseptic, for it prevents the development of bacteria even in a 1 to 2000 solution. It has an agreeable odor, irritates the skin but little, diminishes the discharge of wounds, and is only slightly poisonous; but it is very expensive.

It is employed in aqueous solution, 1 to 1000, with the addition of 10 parts alcohol, and 20 glycerine; and in thymol-gauze, made by impregnating 1000 parts gauze with 500 parts spermaceti, 50 parts resin, and 16 parts thymol.

In the treatment of burns, the addition of $1\,^0/_0$ thymol to the liniment which is used everywhere for burns (equal parts linseed oil and limewater) renders it analgesic and antiseptic. A 1 to 1000 solution is also to be warmly recommended as a mouth-wash.

10. NAPHTHALINE (E. Fischer).

Naphthaline is a very good antiseptic, which does not irritate the wound, is not poisonous, and is very cheap, but it has a very unpleasant, penetrating odor.

When sprinkled over open wounds in the form of powder, it disinfects them quickly and durably. Gauze, with naphthaline rubbed into it, makes a very useful material for antiseptic dressings.

11. PEROXIDE OF HYDROGEN (Trommsdorff).

Peroxide of hydrogen is a very strong and not poisonous antiseptic, which acts very powerfully in a $3\,^0/_0$ aqueous solution, used as a spray, in disinfecting foul wounds, as well as sick-rooms, but it is unfortunately too expensive.

12. ABSOLUTE ALCOHOL.

Absolute alcohol is a moderately strong antiseptic, which is very useful for the disinfection of instruments, especially knives, the edges of the latter not being liable to be attacked by it.

ANTISEPTIC POWDER DRESSINGS.

Antiseptic powder dressings, that is, the sprinkling of antiseptic substances in the form of powder, are suitable for:

a. Such wounds as may be expected to **heal under the scab** (penetration-fractures, simple gunshot wounds, superficial burns).

b. Fresh contused and lacerated wounds of considerable size (caused by the explosion of bombs, or by machines) which are not united by suture, and therefore can not heal by first intention, as well as large and deep burns — in order to prevent decomposition.

c. Suppurating wounds, in order to diminish the discharge, and produce healthy, quickly-cicatrizing granulations.

d. Septic, gangrenous wounds, to correct the sepsis.

These powders, however, must not be strewn in fresh wounds which are to be closed by suture, because they may act as foreign bodies, and prevent union by adhesion.

Only those antiseptic substances are suitable for use in this way which do not irritate the wound — that is, do not increase the discharge, but rather diminish it. This purpose is best fulifilled by

IODOFORM POWDER (v. Mosetig)

because its antiseptic action is not only tolerably strong, but it is lasting. It is, therefore highly to be recommended for sprinkling in small gunshot wounds which it is not desirable to disinfect thoroughly. In very large wounds (from exploding bombs, etc.) care is necessary, because symptoms of poisoning are sometimes observed. In such cases the mixture of some indifferent substance (chalk, talc, sawdust, peat) with the iodoform is advisable, if iodoform gauze or other material is not at hand for an antiseptic dressing.

The following substances can also be used for powder dressings, — the carbolic powder of Bruns, carbolized lime (Port), naphthaline (Fischer), oxide of zinc (Socin, Petersen); especially the last, for it is harmless, odorless, and cheap, and has some antiseptic power, while subnitrate of bismuth (Kocher) is sometimes poisonous; but both form concrements when strewed in wounds containing cavities.

Salicylic acid is not to be recommended for sprinkling on wounds as a powder, for it irritates the wound too much, and causes pain. It is also poisonous in large quantities, and affords no protection against erysipelas (Küster).

RENEWAL OF THE DRESSING.

The dressing of a clean wound should, if possible, remain untouched until the wound heals, or at any rate be changed as seldom as possible.

In order not to miss the proper time for the renewal of the dressing, it should be frequently examined, especially its most dependent part; the temperature also must be constantly watched by the aid of the thermometer, and the patient's general condition observed.

If the discharge penetrates the dressing and reaches its external surface, decomposition is at once set up in it by the contact of the atmosphere, and rapidly spreads through the layers of the dressing to the wound.

To avoid this, the superficial layers of the dressing at the spot where the discharge has made its appearance must be at once disinfected by washing with bichloride solution, and then covered with an antiseptic cushion extending far beyond the affected place.

If the spot made by the discharge is larger than the palm of the hand, it is better to remove the external layers of the dressing, the large external cushion, and after abundant irrigation of the internal layers below it with bichloride solution, to apply a fresh large cushion.

A renewal of the dressing will be necessary:

1. If great pain is felt in the wound.

2. If fever appears, with such general disturbance that sepsis of the wound is probable (septic fever); but if the general condition continues good, in spite of a rise of temperature, the skin and tongue remaining moist (aseptic fever), it is to be concluded that there is no sepsis of the wound.

3. If a foul odor arises from the dressing.

4. If rubber drainage tubes have been placed in the wound, it will be necessary to change the dressing in a few days (four or five), in order to remove the drainage tubes at the proper time. If they are allowed to remain longer then necessary, they increase the discharge.

The change of the dressing must be made as rapidly as possible, so it is necessary to have everything which can by any chance be needed for it ready beforehand.

Before removing the dressing, the patient is placed in such a position that the fresh dressing can be readily applied, and the bed is to be protected from dirt and moicture by covering it with a rubber cloth.

A large, powerful pair of shears is exceedingly useful for rapidly cutting the bandages (see Fig. 163, plaster of Paris shears).

If the wound is found to be antiseptic, it is entirely unnecessary to irrigate it. The neighboring parts are merely to be cleansed with wipers or bunches of cotton which have been dipped in bichloride solution, and a fresh dressing is to be quickly applied.

If rubber drainage tubes were inserted, they are to be withdrawn, and only to be replaced (after having been cleansed), when some discharge from the deeper parts of the wound appears upon pressure.

If the wound has healed, except some superficial granulations, some borated lint, or a piece of gauze spread with borated vaseline, is laid upon it.

If there is eczema in the neighborhood of the wound, the inflamed part is to be thickly covered with salicylic glycerine ointment, or salicylic vaseline.

If no primary union has taken place, another antiseptic dressing is to be applied and renewed more frequently.

But if the wound has become septic, if inflammation, suppuration, lymphangitis, abscesses, or erysipelas has appeared, all the stitches must be removed at once, and the wound freely opened, and thoroughly disinfected and drained, as will be fully described farther on (see secondary antisepsis, in Part II., Operative Surgery).

THE OPEN TREATMENT OF WOUNDS.

The open treatment, leaving the wound without any dressing (Bartscher, Burow), attained far better results than any treatment which had previously been tried, for in the older methods all sorts of injurious influences had been brought to bear on the wounds. Among these injurious influences were, in particular, frequent renewal of the dressings, retention of the discharges, and the use of lint, old linen, sticking plaster, and other dressing which contained the agents of decomposition.

The method has also undoubtedly rendered service by drawing the attention of surgeons to these injurious influences. But as this method foregoes primary union, allows the agents of infection which exist in the air to have free access to the surfaces of the wound, and permits the discharge to decompose, it should be employed only when there is some reason why the rational antiseptic treatment of wounds, previously described, can not be carried out. It is still less suitable for military practice, because the air of rooms which contain many wounded persons is usually full of the agents of infection.

TREATMENT OF INFLAMMATION (Antiphlogosis).

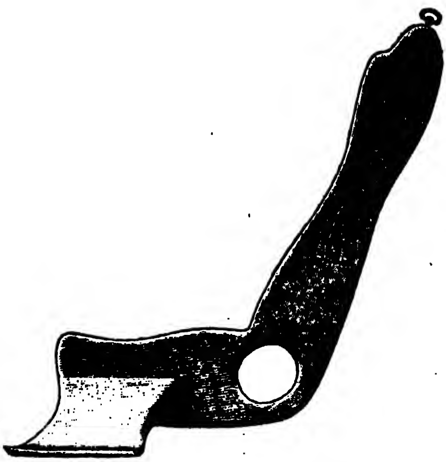
Rest, elevation, and **cold applications** are the principal means of treating **inflammation** of those tissues which are not in contact with the atmosphere. **Antisepsis**, in the widest sense of the word, combats inflammation in wounds of any kind.

A large part of the following chapter deals with **rest** for injured and inflamed parts.

Elevation of the part assists the return circulation of venous blood and of lymph, diminishes the arterial blood supply, and thus acts against congestion (hyperaemia), and quickens the absorption of extravasations and exudations.

The following methods can be employed to elevate the **hand**;

Fig. 51.



Volkmann's suspension-splint.

a. My **adjustable inclined plane**, which stands upon a table near the bed (see Fig. 55); or on the bed, upon a board, arranged to conduct the water used for irrigation into some vessel (see Fig. 57).

b. For **vertical suspension** of the hand and forearm, the entire arm is to be secured to a splint, such as is used in resection of the elbow, or to Volkmann's suspension-splint (Fig. 51), by a bandage applied with spiral turns which do not overlap (see Fig. 60) not with circular turns, and the splint supported in an elevated position by a string attached to its lower end (Fig. 52).

To elevate the **lower extremity** one of the various forms of apparatus used for this purpose can be employed (Petit's fracture-box, the double inclined plane, etc.), or the limb, enclosed in an immovable dressing, is suspended by strings and pieces of wood so that the foot is higher than the rest of the body (Fig. 53).

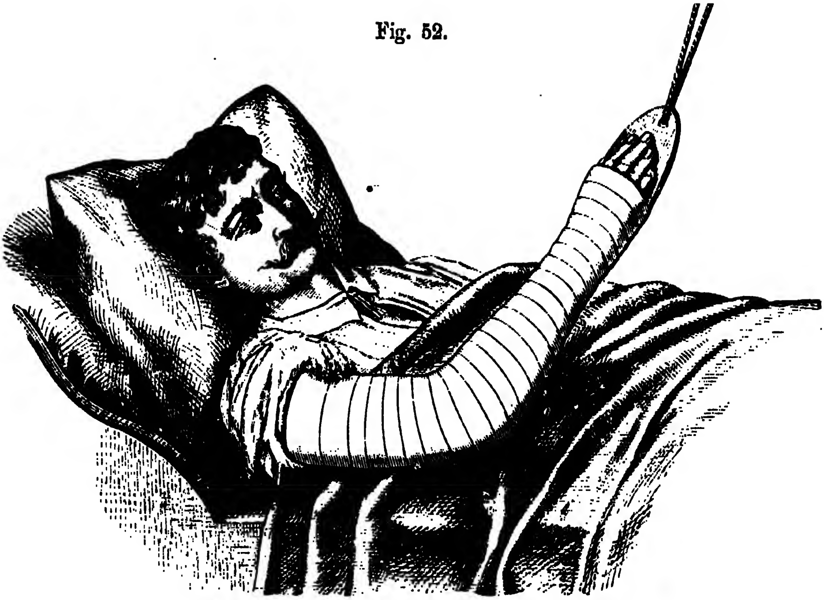
For similar reasons, the prone position is to be chosen in injuries of the back, and elevation of the head and neck practiced in injuries of these regions.

COLD APPLICATIONS.

Cold applications are made, or **heat abstracted** in various ways, when it is desired to reduce the temperature of any part of the body.

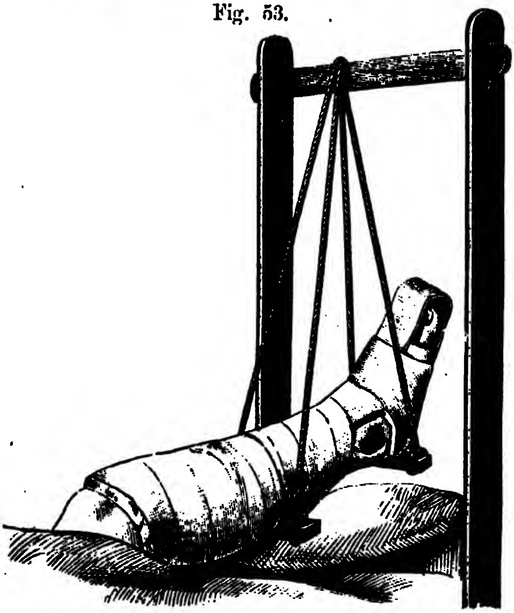
1. By **cold compresses**; these require very frequent renewal, if they are really to abstract heat continuously, and thus the injured

Fig. 52.



Suspension of the hand, according to Volkmann.

Fig. 53.



Suspension of a fenestrated plaster splint for open treatment after resection of the ankle.

part is liable to be disturbed. If they are allowed to remain long enough to grow warm, they act as **excitants** (Preissnitz's compresses).

Fig. 54.

Ice-bag.

2. By **dry cold**, best applied by means of **ice** in rubber bags (ice-bags).

The ice-bags must be securely closed by tying the **closed** mouth of the bag tightly around a wooden cylinder or large cork (champagne cork) with a narrow bandage (Fig. 54).

If the **cold is too intense**, a few **layers** of **linen** or **gauze** are to be placed between the ice-bag and the body.

Pig-bladders are apt to allow the water to penetrate them, and soon decay. To avoid the first, they should be rubbed with lard, inside and out, before being used. The decay can be prevented by washing them in antiseptic solutions every time before filling.

Ice-bags of **parchment paper** do not remain water-tight long, and as they sometimes tear, the patient may be suddenly flooded with the water.

Glass bottles and **tin boxes** filled with ice or cold water, abstract heat more effectively than rubber bags, but they do not fit so well to the body. But cold bottles can very easily be made useful in practice among the poor, and in case of need in war.

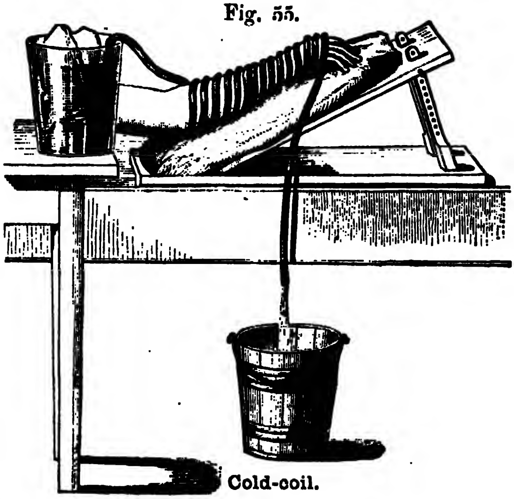
A very great reduction of the temperature in inflammation situated in the extremities can be attained by the **cold-coil** (Fig. 55). I gave this name to a long rubber tube which is wound in spiral turns around the inflamed part, and one end of which, provided with a perforated pewter nozzle, is dropped into a vessel full of ice-water, while the other end hangs in an empty vessel. By applying suction to the latter end, a stream of ice-water can be set in motion, and this can be regulated by compression exercised on the lower end by a string tied a round it. When the upper vessel is empty it can be refilled by pouring the water back again into it from the other. [1])

I have also endeavored to make use of the same method for reducing the temperature of the entire body in the febrile diseases (typhus, scarlet fever, etc.), by having a long rubber tube sewed upon

[1]) Verhandlungen der Deutschen Gesellschaft für Chirurgie. Vierter Congress, 1875, p. 97.

a sheet so that it covered one side of it, in close-lying parallel coils. If this cold sheet is spread over the naked body and a stream of

Fig. 55.



Cold-coil.

Fig. 56.

Leiter's cold-coil for the head.

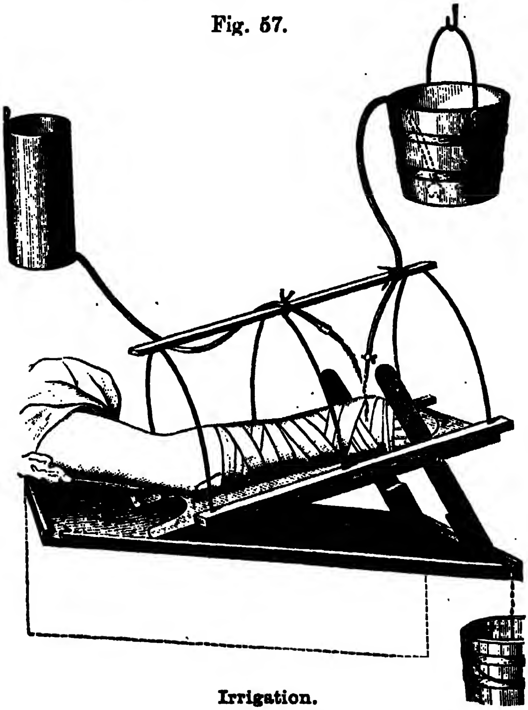
ice-water allowed to run through the tube, the temperature can be greatly reduced in a short time, without the necessity of wetting the patient or of removing him from bed.

Leiter has employed a thin flexible lead tube for the same purpose, and this abstracts heat even more rapidly and energetically; for, as is well known, metal is a much better conductor of heat than rubber (Fig. 56).

3. By letting cold **water drop** upon the part (**irrigation**) (Figs. 57, and 58).

Cold water is made to drop from an irrigator hung above the bed upon the injured part, covered with a linen cloth in which the

Fig. 57.



Irrigation.

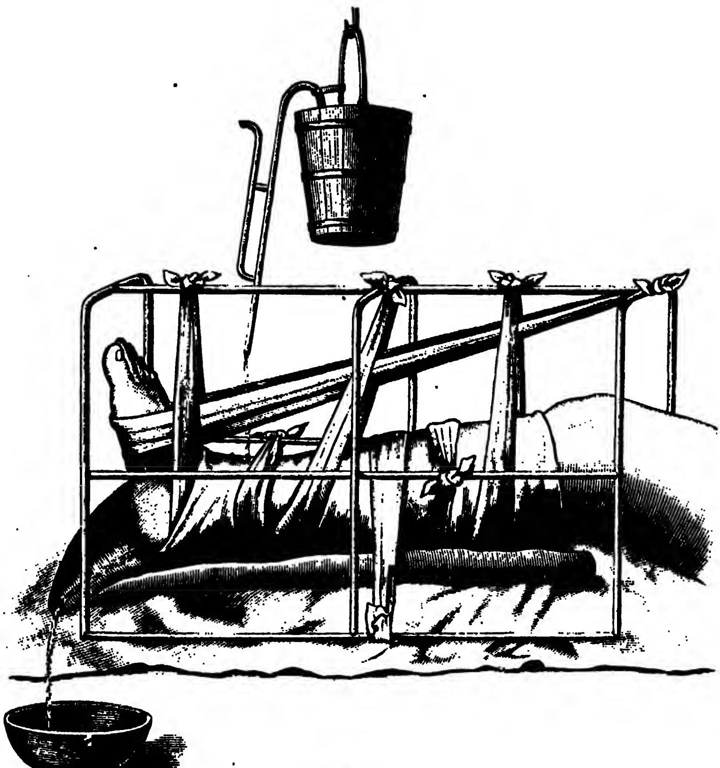
water distributes itself. The rapidity of the dropping can be regulated by sticking straw into the opening in the metal nozzle of the irrigator. Instead of the irrigator, a rubber tube can be used, provided with a stop-cock at one end, and with a pewter nozzle at the other, which can be dropped into a vessel of water. The tube acts as a siphon, and must be set in action by applying suction to one end. Small siphons of glass, or metal tubing, can also be used for this purpose (Fig. 58). The amount of heat abstracted by irrigation is very great, on account of the evaporation of the water. The water, therefore, need not be of a very low temperature. The overflowing water must be collected by an inclined plane (Fig. 57), or by a waterproof cloth, and directed into a vessel below.

4. By **immersion** in cold water.

For this purpose arm- and leg-baths (Figs. 6, and 7) are employed, the injured limb resting upon strips of bandage which are secured to the knobs on the side of the bath-tubs.

This is an excellent method of reducing the temperature in fresh injuries of the hand and foot. It is not necessary to employ a very low temperature in these continuous baths, as their action is very

Fig. 58.



Irrigation.

powerful. Water at 68° to 72° F. has a very well-marked cooling effect when the bath is continued for some time. The regulation of the temperature, by the addition of cold water, can as a rule be left to the patient.

In the treatment of **chronic inflammatory processes**; exudations of blood and serum; thickening of the cellular tissue, adhesions of the tendons and muscles, and stiffness of the joints, such as occur after injuries of any kind, or resections, and with long-continued fixed dressings,

MASSAGE

can be employed with the greatest advantage. By kneading, pressing, and beating with the oiled fingers, the extravasations and exudations must first be broken down, the adhesions loosened, and the lymphatics cleared; then by rubbing and stroking in a direction away from the extremities, the materials thus set free are moved on towards the heart.

By the application of rubber bandages, by passive and active motion (therapeutic gymnastics), by the galvanic current, and by excitant compresses (Preissnitz), absorption can be still further promoted.

BANDAGES.

Bandages and cloths are employed in applying and securing dressings and splints, and for covering, supporting, and immobilizing injured parts.

They are made of;

a. **Linen** — best of old, soft linen which has been frequently washed; torn, or cut along a thread. Bandages of **new** linen do not lie smoothly, being too stiff.

b. **Flannel,** torn; soft and elastic, and therefore fitting nicely, especially suitable for putting under starch and plaster of Paris bandages.

c. **Shirting,** (muslin) torn; cheaper than linen, and suitable for starched bandages.

d. **Cambric,** cut; very soft, and fit as closely to the body as flannel bandages, but cheaper than the latter; very durable, and easily washed. They are particularly good for securing splints and heavy dressings.

e. **Gauze** (mull), cut; lie smoothly, if they are applied wet; and if they are starched (crinoline) the turns adhere to eachother when dry, so that the dressing can not change its position. They are most frequently used in applying antiseptic dressings, and in making plaster bandages.

f. **Cotton-batting,** cut; are very soft and elastic, and are therefore very suitable for applying under stiff bandages, as well as to fill in the edges of the antiseptic dressings.

THE APPLICATION OF BANDAGES, BANDAGING.

Bandaging must be done with great exactness and care, for an improperly applied bandage is liable to become displaced, and may do great injury by strangulation.

A **strangulating** bandage causes at first **venous congestion;** the parts below the point of constriction swell, with great pain, and become blue and cold (Fig. 59); and if the strangulation is not soon

Fig. 59.

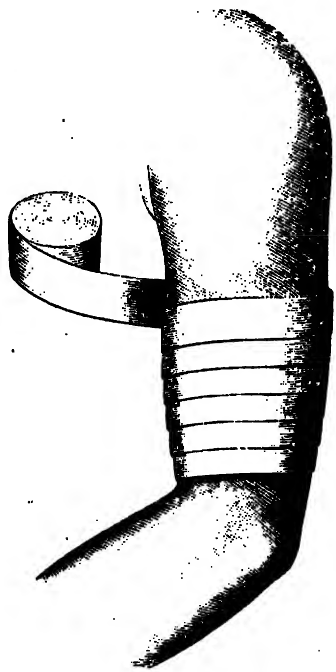
Strangulation by a tight bandage.

removed, **gangrene** follows, or an incurable degeneration of the muscles which have been thus shut off from the circulation for some time (ischaemic paralysis and contracture of the muscles Volkmann).

Fig. 60.

Circular and spiral bandage.

Fig. 61.



Continuous bandage.

If bandages are applied **dry** and made wet afterwards (by cold compresses, for instance), they shrink very much, and cause strangulation.

In **bandaging,** the following **methods** are to be distinguished:

1. The **circular,** which surrounds the part at one level (Fig. 60, the lower part of the figure).

Fig. 62.

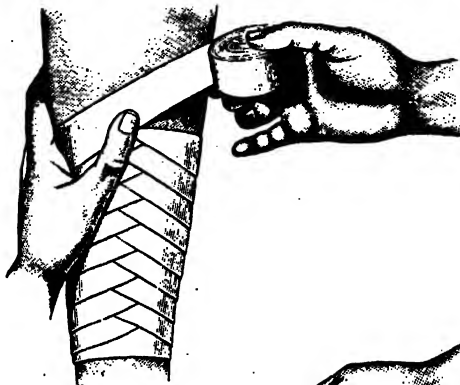
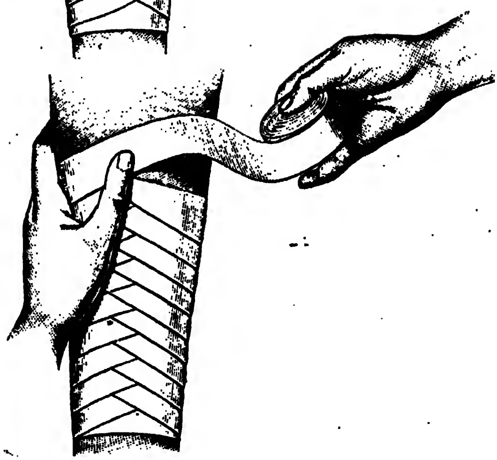


Fig. 63.



2. The **spiral** (dolobra repens), a steep spiral, in which the turns do not overlap (Fig. 60, the upper part of the figure).

3. The **continuous** (dolobra ascendens), a moderately inclined **ascending** spiral, the successive turns of which partly overlap (Fig. 61).

The **descending** spiral (dolobra descendens) is seldom used because it leads to venous congestion.

4. The **reversed** (dolobra reversa) (Figs. 62 to 64) must be employed whenever the circumference of the limb increases or diminishes, in order to prevent separation of the turns of the bandage (Fig. 65). In making the reverse, the thumb of the left hand must be pressed

upon the lower edge of the bandage, so that the upper edge is relieved of tension, and can be easily turned over.

Fig. 64.

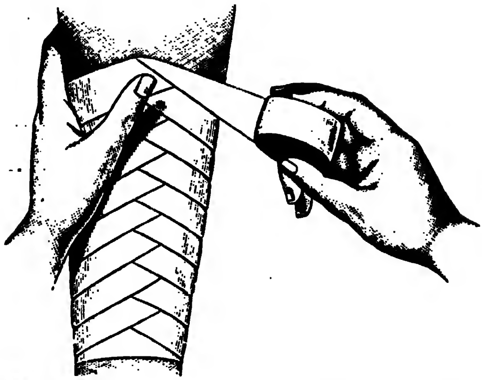
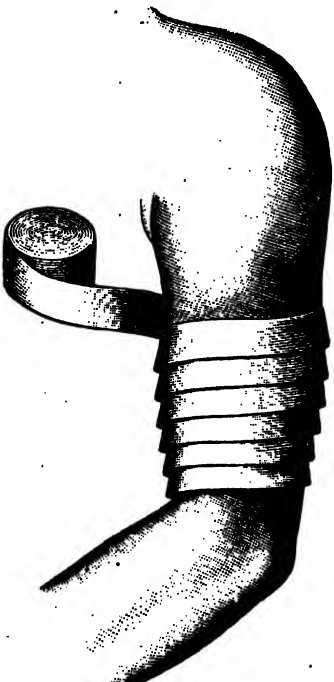


Fig. 65.



• Gaping bandage.

5. The **spica, or figure-of-eight,** is used whenever the bandage passes over a joint to another part of the body (Fig. 66).

6. The **double-headed bandage,** which is rolled at both ends, is used by preference on the head, and on amputation stumps; it can also be em-

Fig. 66.

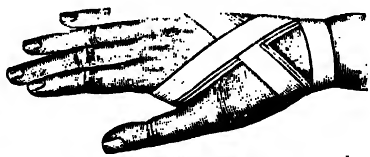


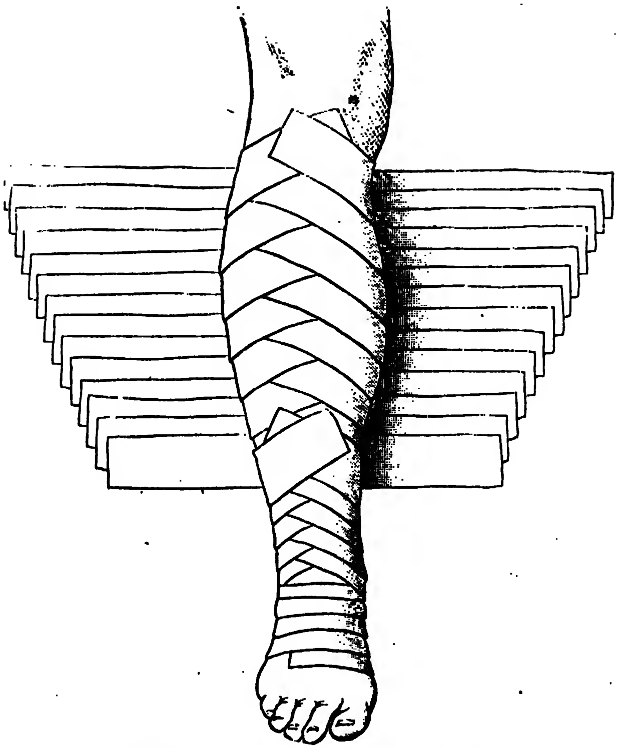
Figure-of-eight bandage.

ployed to draw together the edges of wounds, and of ulcers of the leg (see Fig. 22, p. 17).

5. The **many-tailed** bandage (Scultetus) made of many short strips, overlapping half of their width, is sometimes used in dressing compound fractures, and in making plaster of Paris dressings (Fig. 67).

8. The T-bandage, a strip of bandage, to the middle of which another strip is fastened at right angles to the first, serves for some dressings of the pelvis and head (Fig. 68).

Fig. 67.



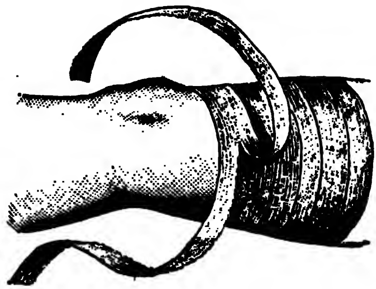
Many-tailed bandage of Scultetus.

Fig. 68.

T-bandages.

To secure the end of the bandage, a pin, or better, a safety-pin, is employed (see Fig. 90). If none is at hand, or economy in pins is desirable, the end of the bandage (especially if it is a gauze bandage) is torn in two, and one half is carried backwards and then tied in front with the other half, as is shown in Figure 69.

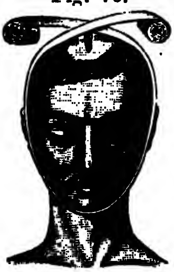
Fig. 69.



DRESSINGS FOR THE HEAD.

1. The **double-headed roller** (fascia uniens) (Fig. 70). The middle of the bandage is applied opposite the injured spot, and the heads of the roller are brought around over it, then back to the starting point, and these turns are repeated several times, alternately covering eachother behind and in front.

Fig. 70.



Double-headed roller.

Fig. 71.

Sagitall bandage.

2. The **sagittal bandage** (fascia sagittalis) (Fig. 71), a T-bandage which is particularly well suited for bringing together transverse wounds of the scalp.

3. The **knotted bandage** (fascia nodosa) (Fig. 72), a double-headed bandage, the turns of which are crossed at right angles over the wound with considerable force, as in tying up a bundle, is especially useful in case of need in wounds which bleed profusely, and upon which it is necessary to exert great compression. A tightly drawn cravat, or a piece of rubber tubing can be used for the same purpose.

4. The **halter-bandage** (capistrum) (Fig. 73). The first turn begins upon the top of the head, surrounds the face, passing under the chin, and returns to the top of the head. The second turn runs from this point around the back part of the head, then from the nape of the neck forwards, and around the anterior surface of the chin, returns to the nape of the neck, and passes back again to the top of the head. After both of these turns have been repeated two or three times, the third part surrounds the forehead and the back of the head by a circular turn.

NB. This bandage, as well as the following, is especially to be recommended for practice, because the different turns can be used in various dressings. They are both most easily applied by using wet gauze bandages.

5. The **recurrent bandage** of the head (mitra Hippocratis) (Fig. 74), a double-headed bandage, of which one head, by circular

Fig. 72.

Knotted bandage.

Fig. 73.

Halter bandage.

Fig. 74.

The cap of Hippocrates.

turns around the forehead and occiput, secures the turns of the other head of the roller, which pass alternately over the right and left parietal bones, overlapping for half of their width.

6. The various turns of the **halter bandage** serve for injuries of the **temple** and **cheek** (Fig. 73).

Fig. 75.

Four-tailed bandage of the jaw.

Fig. 76.

Nose bandage.

Fig. 77.

Eye bandage.

7. The **eye bandage** (monoculus) is used for injuries of the eye (Fig. 75).

8. The **nose bandage** is employed in injuries of the **nose**, and is made of a broad strip of bandage folded together (Fig. 76).

9. In injuries of the **lower jaw**, the **fourtailed bandage of the jaw** (funda maxillae) (Fig. 77) is used — a bandage 5 feet long, $2^1/_2$ inches wide, split at both ends, leaving a piece in the middle $2^1/_2$ inches wide not split, and making four ends of equal length. The middle piece, having had a small slit made in it, is laid over the middle of the chin, the upper ends are led backwards over the occiput, and thence

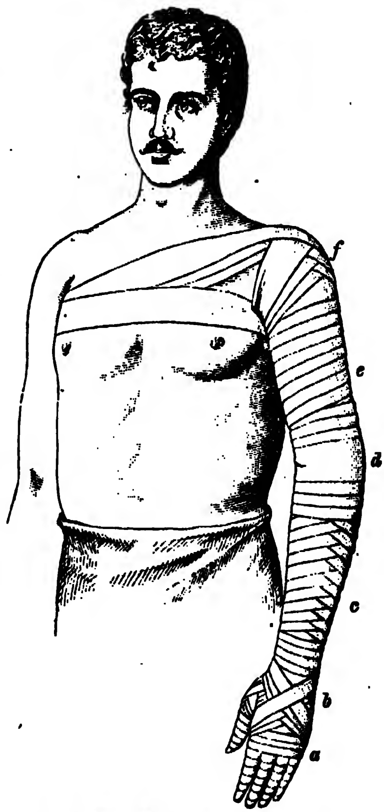
to the forehead, and the lower ends are led upwards over the temples and down on the opposite sides.

DRESSINGS OF THE UPPER EXTREMITY.

1. In bandaging the entire **upper extremity,** bandages are first applied to each **finger,** and the whole hand bandaged with narrow bandages (**glove bandage, chirotheka**) (Fig. 78, a and b).

Next follows the bandage of the **forearm,** with a reversed continuous bandage (Fig. 78, c); then the **elbow,** with a figure-of-eight (testudo) (d); the **arm** proper, with a simple spiral (e); and the **shoulder,** with the spica of the shoulder (f).

Fig. 78.



Bandage of the hand and arm.

2. Dressings for injuries of the **hand** and **fingers.**

General rules: — no strangulation; unbutton the shirt; cut open the sleeves of the shirt and under-vest up to the shoulder; bandaging of the hand must not be begun by circular turns around the wrist; the hand must not be allowed to hang down.

Fresh simple wounds are to be brought together with English sticking-plaster, wet gauze bandages, or strips of dry gauze painted with collodion or traumaticine, or fine sutures — the epidermis sutures of Donders. Hemorrhage is usually to be controlled by pressure — bandaging.

3. **Contused** and **lacerated wounds** of the fingers are treated by narrow gauze bandages which have been moistened with weak carbolic, or salicylic solution, and are from time to time moistened again by dipping them into the same, or by irrigation: still better is a complete antiseptic dressing.

4. **Fractures** of the **fingers** are treated by a **plaster-splint** (bandaging with narrow flannel bandages — chirotheka, and over that

narrow plaster of Paris bandages); or by **simple splints** (narrow thin wooden splints wrapped in cotton batting), secured by wet gauze bandages, and paste spread over them, or by dry gauze bandages, painted with collodion or traumaticine.

5. **Fracture** of a single **metacarpal bone** is treated by bandaging the hand with flannel bandages upon a ball (a large bunch of cotton) placed in the palm — ball-bandage.

Fig. 79.

Figure-of-8 in disarticulation of a finger.

When there is great shortening, **extension** will be found useful — two strips of adhesive plaster being secured to both sides of the finger by a spiral adhesive plaster strip, and extension made by a rubber ring attached to a splint bound to the hand.

6. After **disarticulation** of one **finger,** a compressive bandage can be formed by a narrow figure-of-eight bandage (Fig. 79).

b. In **fracture** of the **clavicle,** displacement of the ends can be corrected, although not permanently, by Desault's dressing for fracture of the clavicle. This dressing has, indeed, gone out of fashion but it is excellent for practice, for some of the turns are employed in nearly all dressings about the shoulder.

The **first part** (Fig. 80) secures a wedge — shaped cushion in the axilla, the arm being held in abduction, by turns encircling the chest.

Fig. 80. Fig. 81.

First part. **Second part.**
Desault's dressing for fracture of the clavicle.

The arm having been lowered and pressed against the cushion, is fixed to the chest and at the same time drawn backwards by the **second part** (Fig. 81).

The **third part** (Fig. 82) supports the arm like a sling.

To prevent the bandage from slipping, paste may be spread over it, or it may be sewed together in numerous places with needle and thread.

The dressing of Velpeau (Fig. 83) which secures the hand of the injured side upon the sound shoulder, and the elbow in front of the

Fig. 82.

Desault's dressing. Third part.

Fig. 83.

Velpeau's dressing for fracture of the clavicle.

ensiform appendix of the sternum, is useful both in fracture of the clavicle, and in chronic inflammation of the shoulder-joint.

DRESSINGS OF THE TRUNK.

1. Bandage for the chest (Fig. 84).
2. Figure-of-eight for the back (Fig. 85).

Fig. 84.

Fig. 85.

DRESSINGS FOR THE LOWER EXTREMITY.

Bandaging the entire lower extremity (Fig. 86) is begun by bandaging the foot with a narrow bandage in figure-of-eight turns (**stirrup bandage,** stapes).

The leg is next bandaged with a broader continuous reversed bandage, the knee by a figure-of-eight (testudo), the thigh by a continuous reversed bandage, and the hip by a figure-of-eight (spica of the hip), which is finished by a few circular turns around the pelvis.

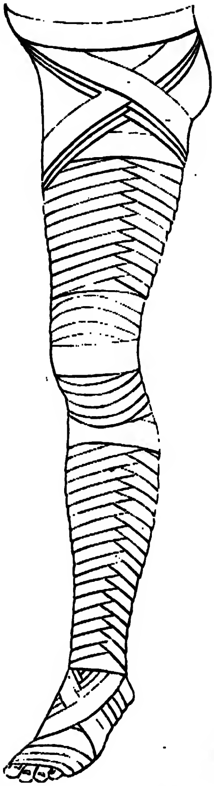
Many of the bandages which have been figured are obsolete, and are little used, if at all, in practical work. But they are all very useful for **practice**, and although it is easier to apply a wet gauze bandage than one of stiff linen, still a complete mastery of the art of bandaging is necessary for making proper antiseptic dressings.

Fig. 87 shows, by way of example, how a well-applied antiseptic cushion-dressing appears after an important operation in the region of the neck.

HANDKERCHIEF DRESSINGS.

Almost every dressing can be secured by **linen or cotton cloths,** triangular (neckerchief), or square (handkerchief) in shape, and sometimes better than by bandages; their application requires little or no

Fig. 86.



Bandage of the lower extremity.

Fig. 87.

practice, and the danger of strangulation is far less than in bandage-dressings.

These dressings are therefore particularly suitable for temporary or emergency dressings, and especially for „first aid" on the field of battle. They are also useful in the later stages of the treatment of wounds, for covering stumps, etc.

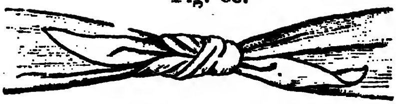
The handkerchief dressings were most warmly recommended as much as fifty years ago, by Gerdy and Mayor, of Lausanne. But as they had passed almost entirely into oblivion, the author exerted himself to secure their admittance again into field practice, by having printed upon the triangular cloths representations showing the application of the handkerchief to injuries of the various part of the body.[1])

As is to be seen in these pictures, the cloths can be employed for various purposes in different sizes and shapes — sometimes as **handkerchief-bandages,** folded together from the point to the bottom into long cravats; sometimes open, as a **triangle,** with varying use of the different angles, by turning in, folding over, tying, or pinning together.

For military use, the handkerchief should be large enough to form a sling for a large man, that is, the base of the right-angled triangle must be at least $1\frac{1}{2}$ yards long, and the material out of which these handkerchiefs are cut must be at least 1 yard wide. If smaller

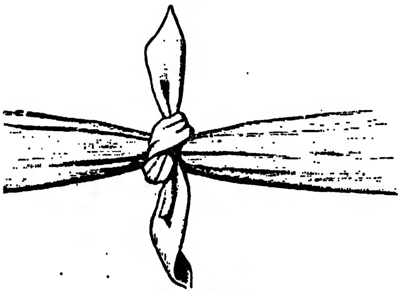
[1]) Esmarch, Der erste Verband auf dem Schlachtfelde. Kiel, 1869.

Fig. 88.



Square-knot.

Fig. 89.



Granny-knot.

cloths are needed, the large handkerchief can be cut in two from the apex to the base with scissors.

For tying the ends together, only the square-knot should be employed (Fig. 88), as it holds much better than the granny-knot (Fig. 89); or the ends may be pinned together. The **safety-pin** (babies' pin, fibula) is best suited for this purpose (Fig. 90).

These handkerchiefs are brought into use in the different regions of the body as follows:

For injuries of the head are employed:

Fig. 90.

Safety-pin.

a. The **triangular bonnet** (capitium parvum triangulare) (Figs. 91 and 92). The middle of the triangular cloth is laid upon the top of the head so that the lower edge lies squarely across the forehead, and the corners hang down over the neck. The two ends are then

Fig. 91.

Triangular bonnet, anteriorly.

Fig. 92.

Triangular bonnet, posteriorly.

passed backwards above the ears, crossed behind over the occiput, brought forwards again and tied across the forehead. The corner which hangs down behind is then drawn down tight, turned up over the occiput, and secured on top of the head with a safety-pin.

b. The **four-tailed bandage** for the head (Figs. 93, and 94), a rectangular cloth, 24 inches long, 8 inches wide, split at both ends like a split compress. To secure a dressing on the top of the head with this cloth, the two posterior ends are to be tied under the chin,

Fig. 93.

Four-tailed bandage for the vertex.

Fig. 94.

Four-tailed bandage for the occiput.

the two anterior ends under the occiput (Fig. 93). On the other hand, to secure a dressing upon the occiput, the anterior ends are tied under the chin, and the posterior across the forehead.

c. The **large square head-cloth** (capitium magnum quadrangulare) (Figs. 95, and 96) covers the entire region of the ears, nape of the

Fig. 95.

Fig. 96.

The large square head-cloth.

neck, and throat, as well as the head, and is therefore a very convenient dressing in cold or bad weather.

A cloth 40 inches square (a napkin), is folded so that the long edge of the upper part lies about 4 inches behind the long edge of the under part. In this way an elongated rectangle is formed which is laid on the head of the patient, so that the middle of the cloth lies over the sagittal suture, the free edge of the lower part hangs down as far as the end of the nose, the edge of the upper part hangs down to the eyebrows, and the short sides of the rectangle fall over both shoulders.

The two outer corners of the four which hang in front over the chest are first tied together under the chin; then the edge of the under

layer, which hangs in front of the eyes, is turned up over the forehead, and its corners are pulled backwards above the ears and tied together at the nape of the neck.

For injuries of the **eyes**, the **eye bandage** (Fig. 97) made of a folded handkerchief is employed.

For injuries of the **lower jaw**, the **four-tailed-bandage** of the jaw (funda maxillae) is used, which is made of two small folded hand-

Fig. 97.

Eye bandage.

Fig. 98.

Four-tailed bandage of the jaw.

kerchiefs, the middle of one being laid upon the anterior surface of the chin, and its ends tied together at the nape of the neck; the other being led from the under surface of the chin over the top of the head (Fig. 98).

In **gunshot wounds** of the bones of the jaw, the mouth must be carefully washed out with an irrigator. The displaced fragments are best held in place by hard-rubber splints, which must be made by a skilful dentist.

In injuries of the neck, the following methods are in use for securing dressings:

1. The **simple neck-cloth** (Fig. 99), made of a triangular cloth folded like a cravat.

Fig. 99.

Neck-cloth.

Fig. 100.

Neck-cloth with paste-board splint.

2. For transverse wounds of the neck the head can be inclined towards the injured side by a piece of stiff pasteboard laid in the cloth (Fig. 100).

a. **Figure-of-eight** for the hand (Fig. 101).

b. **Covering** for the entire hand (Fig. 102, the left hand).

c. **Handkerchief dressing** for the **elbow** (Fig. 102, the right elbow).

Fig. 101.

Figure-of-eight for the hand.

Fig. 102.

Handkerchief dressings for the shoulder, hand, and elbow; and small sling.

d. **Handkerchief dressing** for the **shoulder** (Fig. 102, the left shoulder, front view, and Fig. 103, the right shoulder, rear view).

e. Handkerchief dressing for **amputated arm** (Fig. 103, the left arm).

f. Handkerchief dressing for **disarticulation** of the **arm** (Fig. 104).

g. **Slings**, for supporting the arm (mitella):

1. **small** sling (mitella parva) (Fig. 102, the left arm).

2. **triangular** sling (mitella triangularis):

x. the **first**, ordinary, form (Fig. 105) in which both the ends are carried over both shoulders around the neck.

Fig. 103.

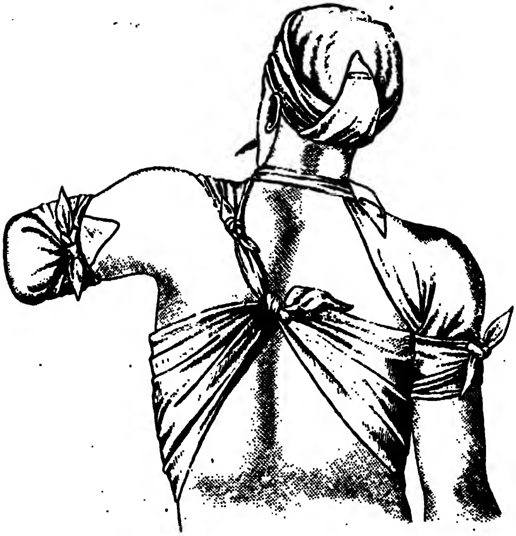


Fig. 104.

Fig. 105.

y. The second form (Fig. 106), in which the ends are carried only over the sound shoulder, so that the shoulder of the injured side may be relieved of pressure.

z. The **third** form (Fig. 107), in which the ends are carried over the shoulder of the injured side, so that the uninjured arm may be left free — for carrying weapons, etc.

3. **Large square** sling (mitella quadrangularis) (Fig. 108), which is made by a large napkin.

Fig. 106.

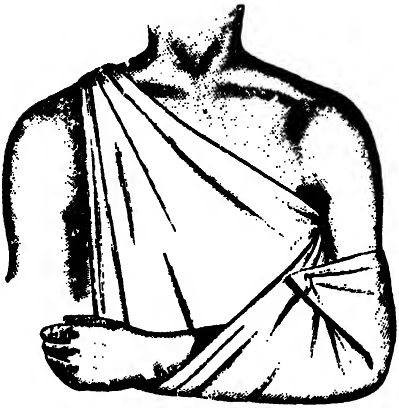


Fig. 107.

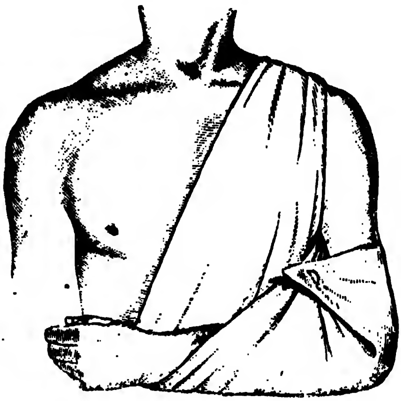


Fig. 108.

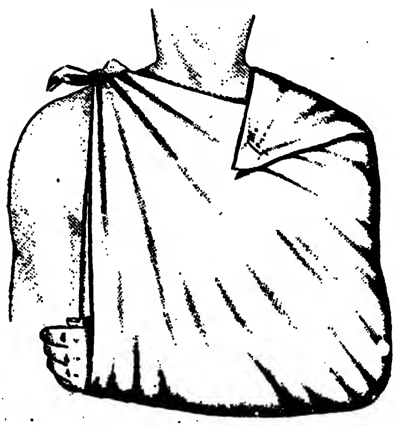
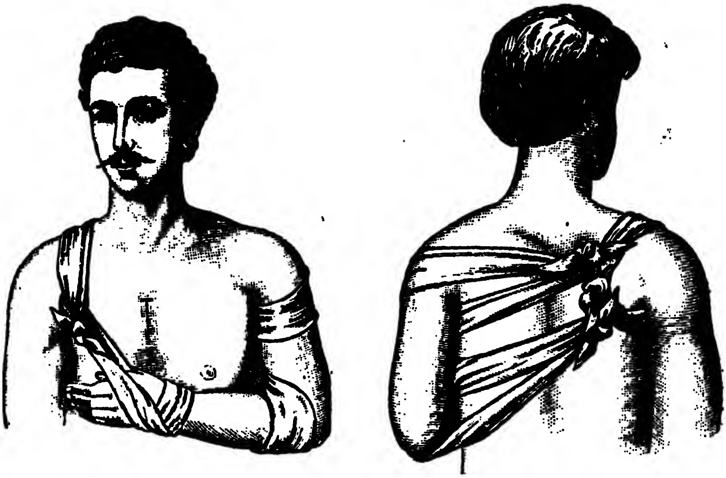


Fig. 109.

NB. The corners are best secured by pins, because the knots are apt to make disagreeable pressure, especially in the nape of the neck.

For better fixation of the arm (after reduction of a dislocation of the shoulder, for instance) a broad cravat is applied over the sling, to press the arm against the chest (Fig. 109).

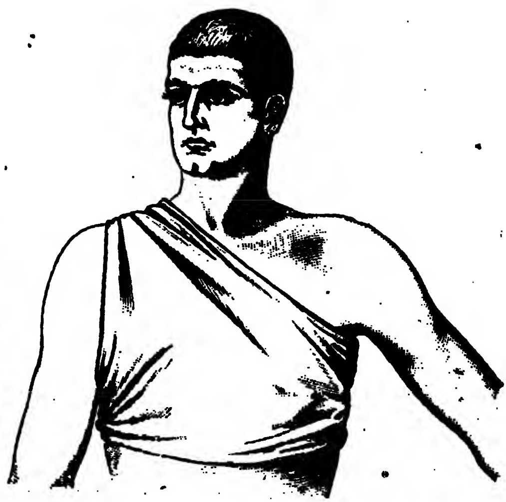
Fig. 110.



Szymanowsky's handkerchief-dressing for fracture of the clavicle.
a. anterior view. **b. posterior view.**

Fig. 111.

Fig. 112.



Handkerchief-dressings for the chest.

Fig. 113.

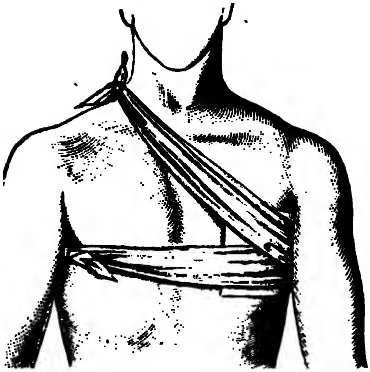
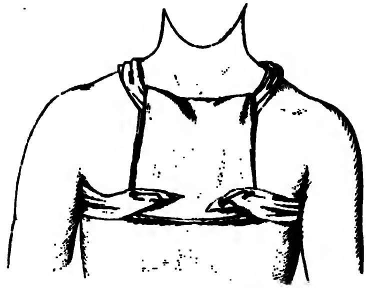


Fig. 114.



Handkerchief-dressings for the chest.

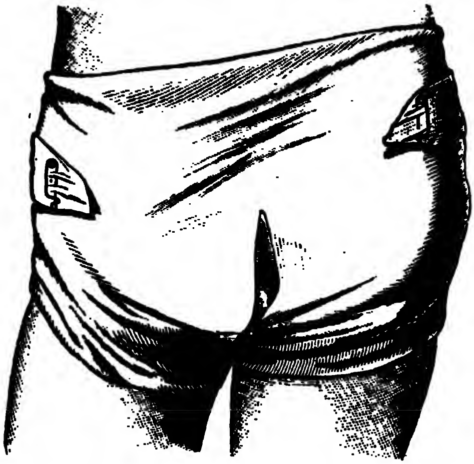
Fig. 115.

Fig. 116.

Fig. 117.

Handkerchief-dressings for the foot, knee, and pelvis.

Fig. 118.



Handkerchief-dressings for the pelvis.

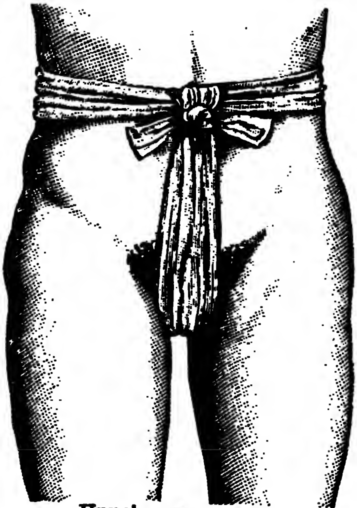
Fig. 119.

Roser's handkerchief-dressing for the groin.

Fig. 120.

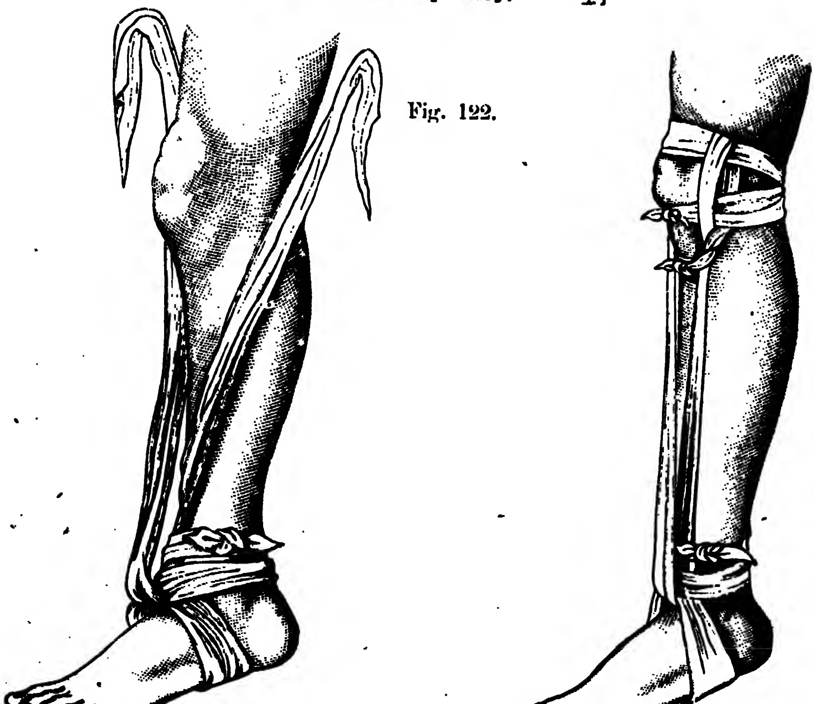
Handkerchief-dressing for the pelvis.

Fig. 121.



Unna's suspensory.

Fig. 122.



Major's handkerchief dressing for fracture of the patella.

SPLINT-DRESSINGS.

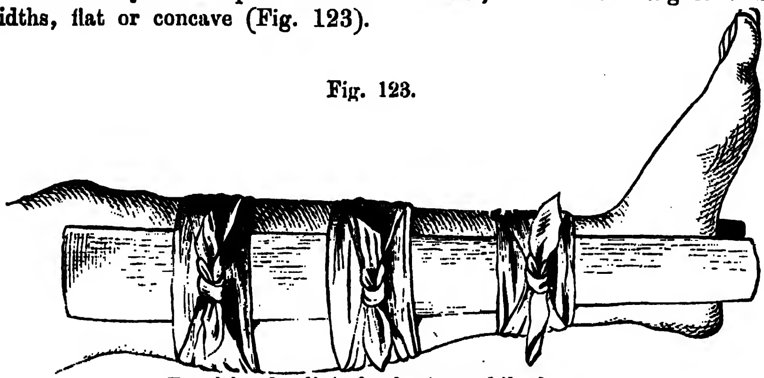
Splints, fastened to the limbs by bandages or cloths, are used for the fixation of fractured bones. They are made of a great variety of materials.

The most frequently used are the following:

1. WOODEN SPLINTS.

Ordinary small pieces of thin **board**, of various lengths and widths, flat or concave (Fig. 123).

Fig. 123.



Provisional splints for fracture of the leg.

A **splint-dressing**, formed by four padded splints (Fig. 124) secured with handkerchiefs is used for simple fractures of the middle of the arm. The entire extremity must be carefully bandaged, from the tips of the fingers up, and supported by a sling. The bandage should not be carried up too high on the inner side, as it is liable to exert too much pressure in the axilla.

Fig. 124.

Splint-dressing for fracture of the humerus.

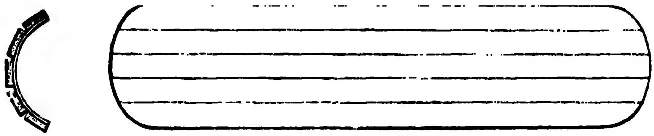
Gooch's **coaptation splints** are made of thin ($^1/_5$ inch) pine wood, which is divided into strips $^1/_2$ inch wide by shallow cuts, not quite penetrating the wood, and glued to leather or linen. They are flexible transversely, unyielding lengthways (Fig. 125).

Schnyder's **cloth splints** consist of splints of flexible walnut veneering 1 to $1^1/_4$ inch wide, and $^1/_8$ inch thick, lying close together, and sewed between two layers of linen or cotton cloth (Fig. 126).

The author's **splint material** (Fig. 127) consists of wooden shavings, $1^1/_2$ inch wide, $^1/_{16}$ inch thick, which are laid parallel to

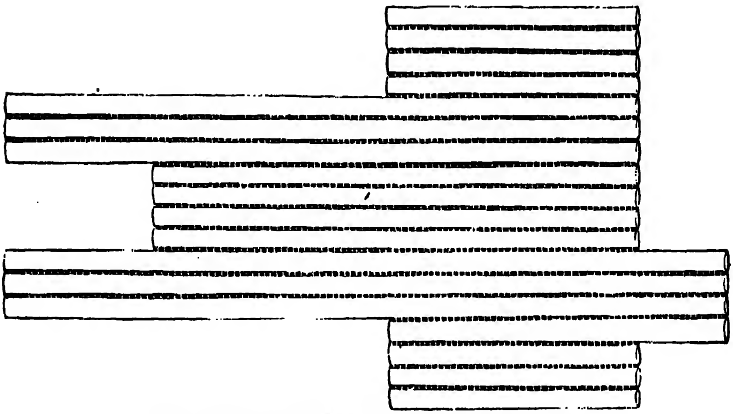
each other, $^1/_5$ inch apart, between two layers of unbleached muslin, and pasted to it with water-glass, or paste. This material is easily,

Fig. 125.



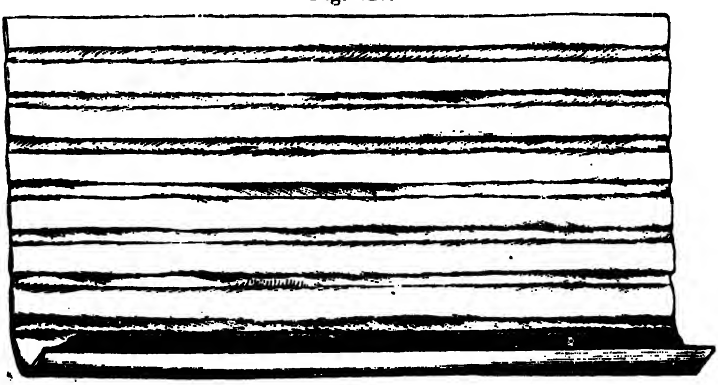
Gooch's coaptation splints.

Fig. 126.



Schnyder's cloth splints for the lower extremity.

Fig. 127.

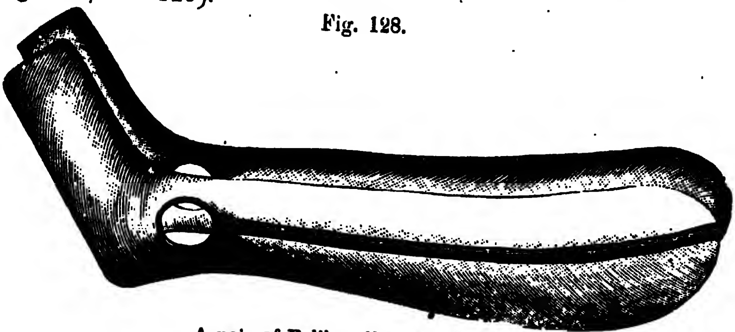


Esmarch's splint material.

quickly, and cheaply made; it can be cut with the regulation military scissors; and when rolled up it can be easily carried to the field of battle in considerable quantities.

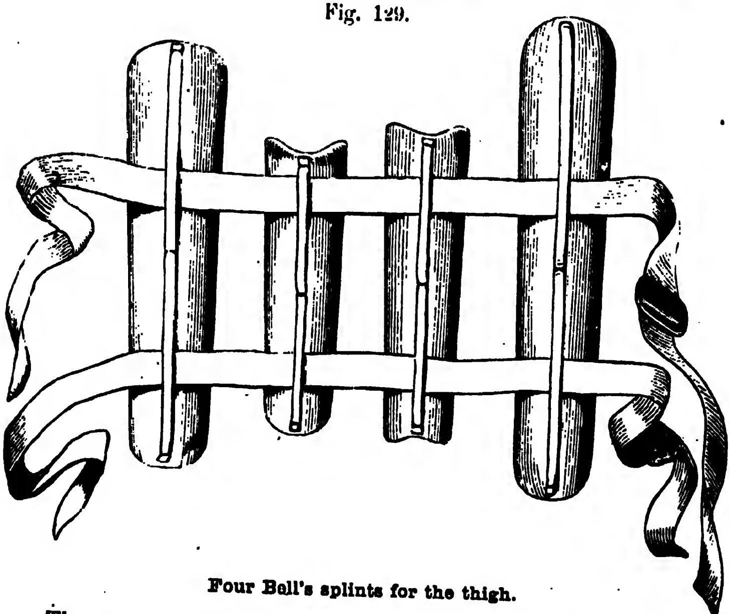
English modeled splints (of Bell, Pott, and Cline), carved from wood, exactly in the form of the limbs, with strips of leather fastened to the outside, under which straps with buckles can be drawn through (Fig. 128, and 129).

Fig. 128.



A pair of Bell's splints for the leg.

Fig. 129.



Four Bell's splints for the thigh.

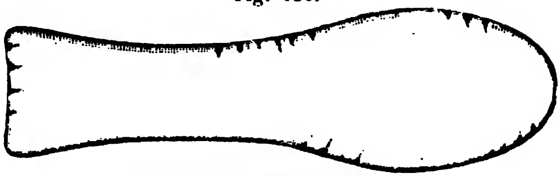
These are padded with cotton, and can be applied, loosened, and removed very easily, especially when the straps are provided with Emmert's buckles (Fig. 129).

Stromeyer's **hand splint,** of thin wood, padded with cotton, and covered with linen or some water-proof material (Fig. 130).

Stromeyer's **padded abduction** splint for fractures of the lower end of the radius (Fig. 131).

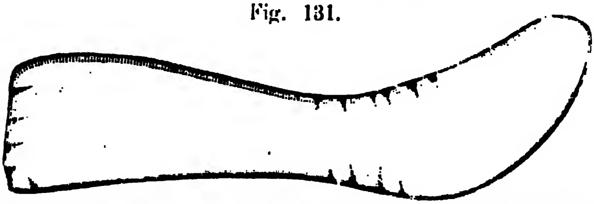
Stromeyer's padded forearm splint for simple and compound fractures of the forearm (Fig. 132).

Fig. 130.



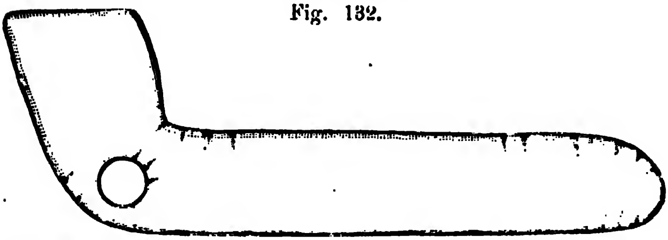
Stromeyer's padded hand splint.

Fig. 131.



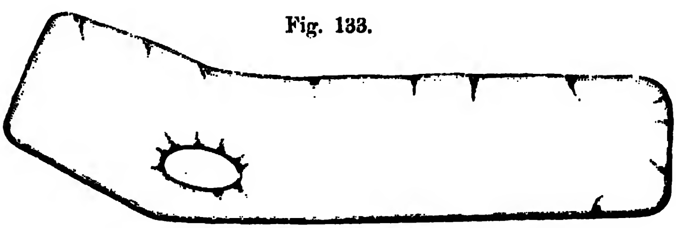
Stromeyer's padded abduction splint for fractures of the lower end of the radius.

Fig. 132.



Stromeyer's right-angled padded splint for fractures of the forearm.

Fig. 133.

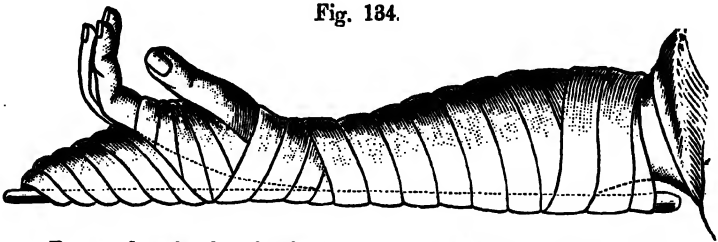


Stromeyer's obtuse-angled padded arm splint.

Stromeyer's **obtuse-angled padded arm splint** with an opening for the internal condyle of the humerus (Fig. 133), which was used in 1849—50 in Schleswig-Holstein for the after-treatment of resection of the elbow, is very useful in contusions, sprains, and inflammation of the elbow, when the application of ice-bags is desired.

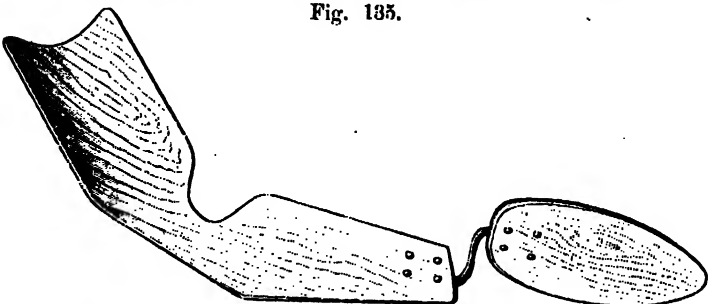
Roser's **dorsal splint** for fracture of the lower end of the radius (Fig. 134), in which the lower fragment is pressed forwards by padding the hand part, and the fingers are left free.

Fig. 134.



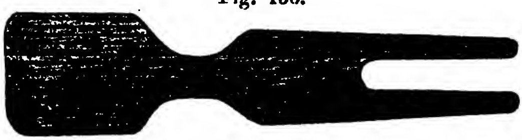
Roser's dorsal splint for fracture of the lower end of the radius.

Fig. 135.



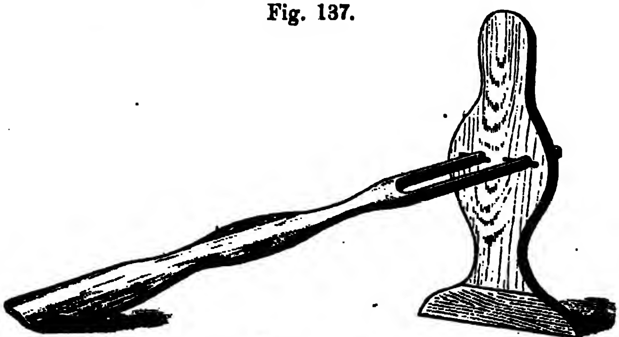
Volkmann's supination splint.

Fig. 136.



Watson's splint for resection of the knee.

Fig. 137.



Vogt's modification of Watson's splint.

Volkmann's **supination splint** for all injuries of the forearm (Fig. 135).

Watson's **splint for resection of the knee** (Fig. 136).

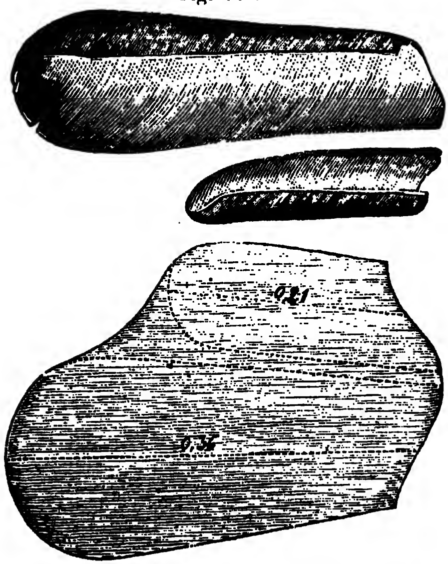
2. PASTE-BOARD SPLINTS.

Splints of any shape can be easily cut from **thick paste-board** with a sharp knife. If they are moistened and firmly bandaged on with a gauze bandage, they fit the shape of the body very well; but give no support until they have dried. They are moreover easily softened by blood, discharge from wounds, rain, or moisture from any other source.

They are most used in connection with the paste bandage.

Moulded paste-board splints, made of softened paste-board, allowed to dry on models of the arms and legs, and then varnished,

Fig. 138.



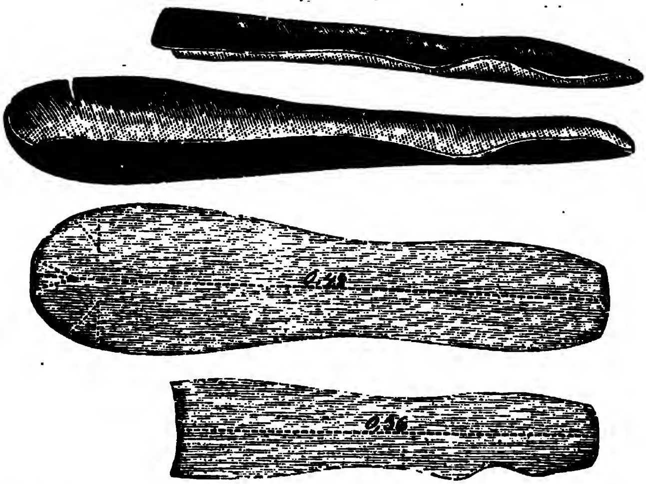
Merchie's moulded paste-board splint for the arm, with pattern.

are light, and fit nicely — that is, if there is a sufficiently large selection of the different sizes at hand.

The double moulded splints of Merchie (Figs. 138 to 141) have been introduced in the Belgian army [1]).

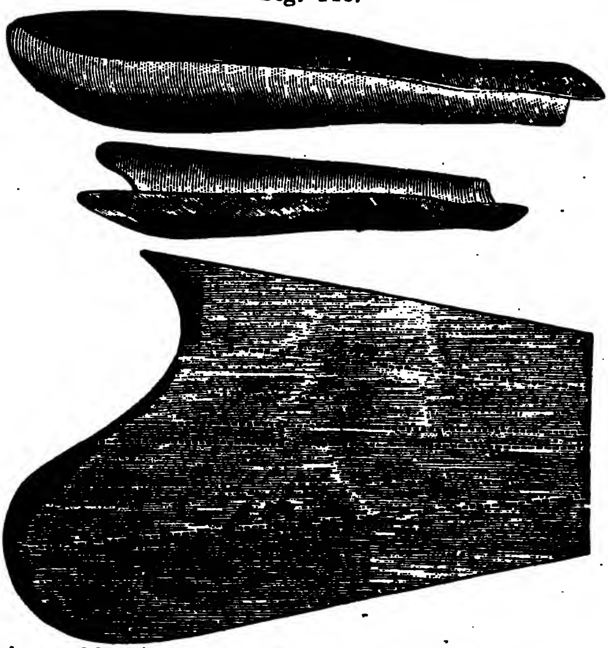
[1]) Merchie: Appareils modelés, ou nouveau système de déligation, etc. Paris, 1858.

Fig. 139.



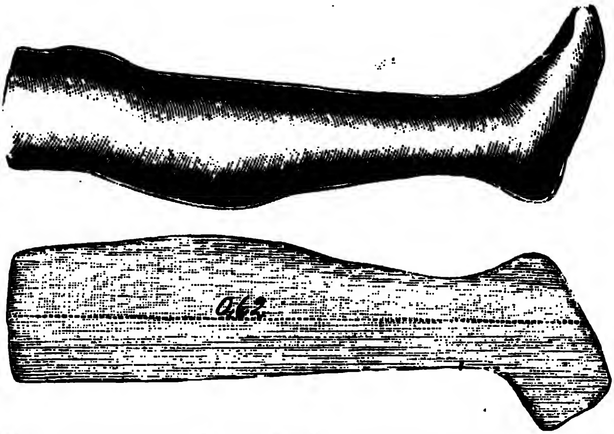
Merchie's moulded paste-board splint for the forearm, with pattern.

Fig. 140.



Merchie's moulded paste-board splint for the thigh, with pattern.

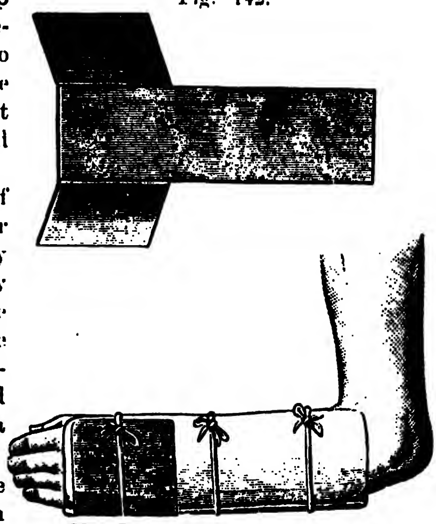
Fig. 141.



Merchie's moulded paste-board splint for the leg, with pattern.

Von Dumreicher's **flap splint** for fractures of the forearm (Fig. 142) is intended to hold the fractured ends of the bones apart, and thus prevent them from uniting in a crossed position.

Fig. 142.



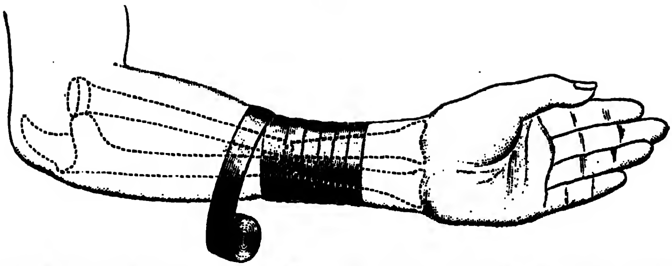
Von Dumreicher's flap splints.

The transverse section of the forearm is not a circular figure, but an ellipse, hence any circular bandage has a tendency to change this shape to a circle (Fig. 143), and would press the fractured ends towards the central axis of the forearm, and might cause them to unite in a crossed position.

Von Dumreicher therefore places a paste-board splint on the palmar side of the forearm, and another on the dorsal side, in a position midway between supination and pronation, and over these the pasteboard splint with the two flaps.

For the same reason Volkmann has recommended the position midway between supination and pronation for all injuries of the bones of the forearm, and has contrived the splint shown in Fig. 135.

Fig. 143.



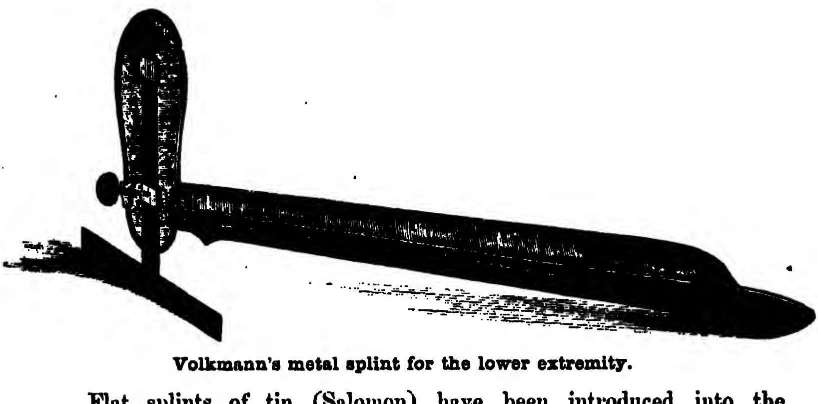
The danger of a circular bandage in fracture of the forearm (after Albert).

3. METAL SPLINTS.

Splints of **common tin** have been in use for a long time in the armies of all countries, for the support of gunshot wounds of the limbs, and for transport, especially in the form of the **boot** of Petit — a slightly concave splint, with a plate for the foot, and an opening for the heel.

Volkmann has simplified this splint, and provided it with an adjustable iron foot support, which is now in use everywhere (Fig. 144).

Fig. 144.



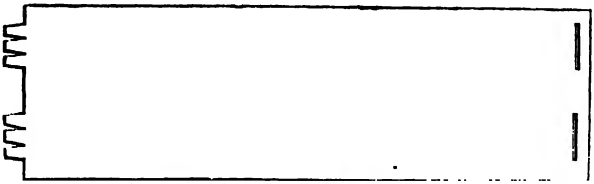
Volkmann's metal splint for the lower extremity.

Flat splints of tin (Salomon) have been introduced into the Danish army. These splints are 14 inches long and 4 wide, provided at one end with two projections, each of which is divided into three teeth, and at the other end with two slits in which the projections of another splint can be inserted and secured by bending, so that splints of any desired length can be easily and quickly formed (Fig. 145).

Splints can be cut out of **sheet zinc** with a strong pair of regulation scissors, and they can then be bent with the hands and fitted closely to the shape of the limbs. In the substitute haversack for the field dressing station, suggested by the author, there is a large sheet

zinc box, which gives shape to the whole, can be used at the dressing-station as a vessel to hold water, and finally cut up into splints.

Fig. 145.

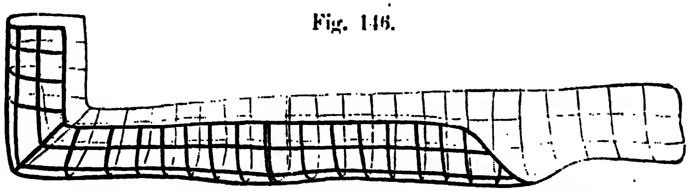


Salomon's sheet-metal splints.

The sheet zinc splints suggested by Schoen and improved by Weissbach (see Deutsche militair-ärztliche Zeitschrift, 1877, Heft 11) which are cut from thin sheet zinc (No. 8, $^1/_{60}$ inch thick) with scissors, according to good patterns, are very convenient for use upon the field of battle.

Baskets are made of **iron-wire** (Mayor, Bonnet), and in these, when well padded, broken limbs rest very well. Flaps can be easily made in them, so that wounds can be dressed without disturbing the position of the limb (Fig. 146). But they are expensive, and take up too much space for use in military practice.

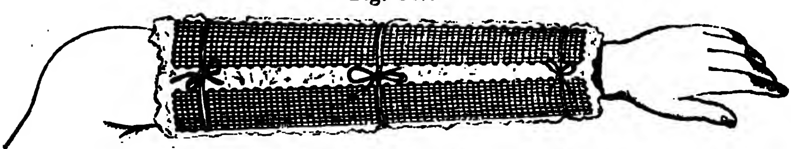
Fig. 146.



Wire-splint for the lower extremity, according to Roser.

It will be shown later how splints of every kind can be improvised from telegraph-wire.

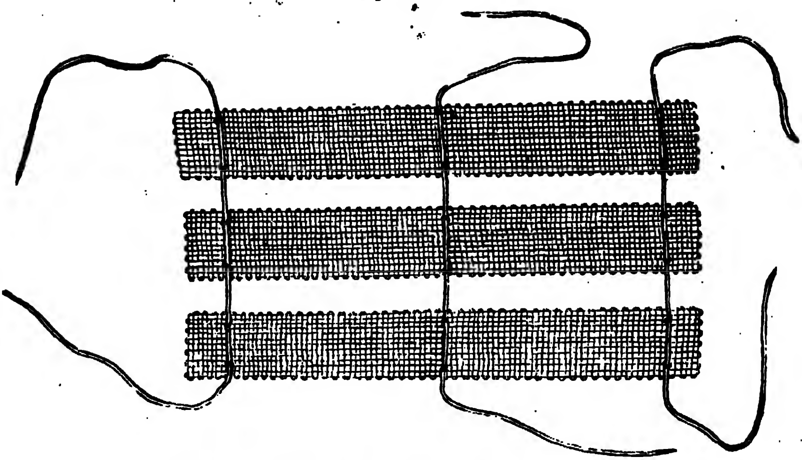
Fig. 147.



Wire-netting splint applied over cotton batting.

Very flexible and airy splints have also been made of commercial **wire-netting** (wire-seive material), which are especially suited for field practice, on account of their lightness and cheapness (Figs. 147, and 148).

Fig. 148.



Three wire-netting splints, connected with string.

4. GLASS SPLINTS.

The glass splints suggested by Neuber for my clinic, for both upper and lower extremities (Figs. 149, and 150) are exceedingly clean, for every spot of dirt can be seen upon them at once, and they can be thoroughly cleaned. If any blood or discharge has penetrated the dressing on the side next the splint, it can be seen immediately.

Fig. 149.

Glass splint for the arm, according to Neuber.

Unfortunately, these splints are so expensive and fragile that they can only be used in richly endowed hospitals, and are totally unfitted for military practice

I have, therefore. recently replaced them with splints of similar shape made of telegraph wire, which have much the same good qualities and are besides much lighter, more durable, and cheaper.

Fig. 150.

Glass splint for the leg, according to Neuber.

IMMOVABLE DRESSINGS.

1. STARCH DRESSINGS.

The starch dressing was invented by Seutin in 1840.

Preparation of the paste. Some starch is stirred with **cold water** to a smooth mass, and then enough **boiling water** is added to make a clear, rather thick mucilage.

Starch bandages are strips of muslin which are drawn through fresh paste and rolled up into roller bandages.

Starch splints are made of strips of paste-board which are dipped quickly into hot water, and then starch paste is thickly spread on both sides.

Application of the starch dressing. The limb is first very carefully bandaged with a wet flannel bandage, after the depressions about the joints have been well padded with cotton. Over this is applied a starch bandage, starch splints are laid outside of this and firmly secured with another starch bandage. The whole is finally covered with a dry cotton or gauze bandage.

Strips of paper can be used instead of the bandages, being dipped into the starch paste and arranged like the many-tailed bandage of Scultetus.

The **cotton paste-board dressing** of Burggraeve is very simple and convenient.

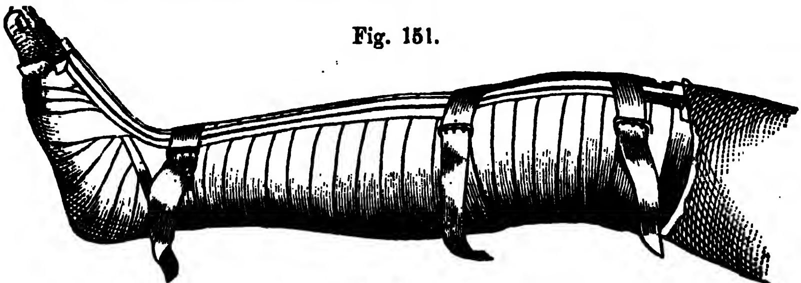
Splints are cut from paste-board in the shape of the limb, starch paste is spread on them, and a layer of cotton-batting laid on one side. The splints are then applied with the cotton covered side next to the limb, and with a dry gauze bandage, beginning with spiral turns which do not overlap, so as merely to hold the splint upon the limb. The

paste is then thickly spread over the bandage with a large brush, or with the hands, and the whole is covered with a dry muslin bandage.

It requires two or three days for a starch dressing to become perfectly dry and hard; and the drying can be hastened by leaving it uncovered, or exposing it to the heat of the sun or of a stove.

To make the dressing **removable**, it is split down its entire length with strong scissors, the splint is bent open, and the edges covered with strips of muslin bandage which have been spread with paste on one side. The dressing can then be again applied to the limb, and secured with straps and buckles (Fig. 151).

Fig. 151.



Removable starch dressing.

2. WATER-GLASS DRESSINGS.

If bandages are soaked in a freshly made [1]), concentrated solution of neutral silicate of potash (**potash water-glass**) which should have a specific gravity of 1,35 to 1,40 (Böhm), dressings can be made with them which will become perfectly firm and hard as soon as the water has evaporated.

To hasten the hardening, finely pulverized chalk, or slacked lime and chalk (1 to 10, Böhm), magnesia (König), or cement (Mitscherlich) are stirred in the water-glass, so as to produce a paste of the consistency of honey, and the bandages are dipped in this, or it is spread over them with a large brush. Finally the entire dressing is sprinkled with the dry powder, and the latter rubbed in. If a little alcohol is painted over this with a brush, a hard, glass-like coating is formed.

3. GUTTA-PERCHA DRESSINGS.

Splints are cut out of sheet gutta-percha $^1/_{12}$ to $^1/_8$ inch thick, and are dipped in hot water at 170° J. until they are flexible, when they are laid upon the limb, which has been previously covered with a wet flannel bandage, and firmly bound on with gauze bandages. Pouring cold water over them makes them harden quickly.

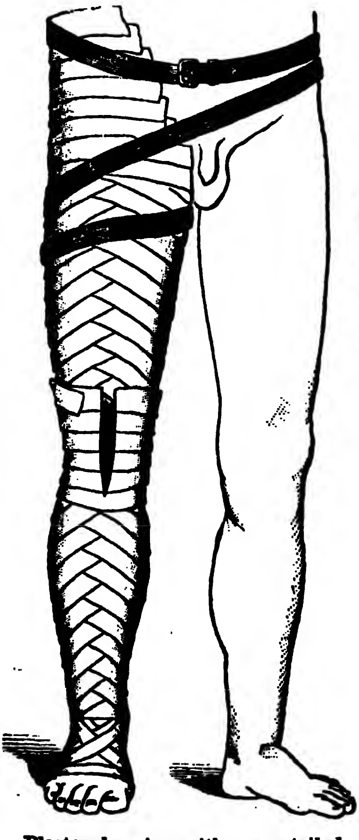
[1]) Solutions which have been kept for some time are irritant, and even caustic to the skin.

4. PLASTER OF PARIS DRESSINGS.

The plaster of Paris dressing was invented by Mathysen in 1852. It has the great advantage over all the others that it becomes firm and hard in a very short time.

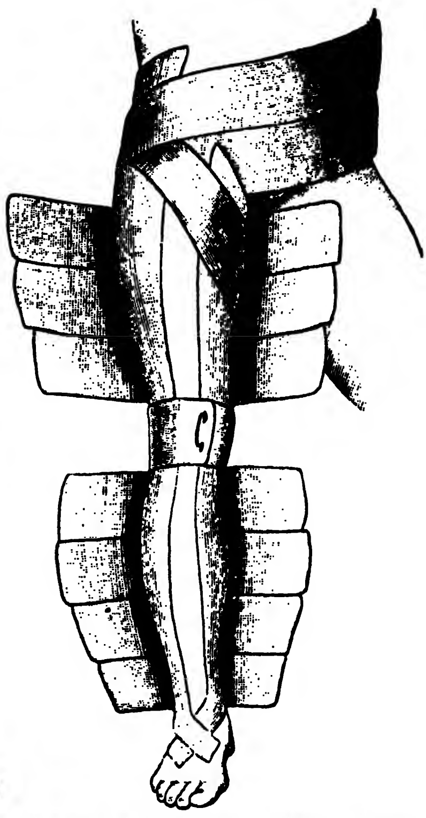
The plaster is best mixed in a china basin, adding to the required quantity of plaster an equal quantity of cold water, with con-

Fig. 152.



Plaster dressing with many-tailed bandage.

Fig. 153.



Plaster dressing made of pieces of coarse sackcloth dipped in plaster.

tinuous stirring, so that a mixture of the consistency of thick cream results. This hardens into a firm mass in five or ten minutes.

To delay the setting of the plaster, more water is used; or starch, lime, milk, beer, or borax are mixed with the water.

To **hasten** the setting, less water is used; or hot water; or table-salt, alum, water-glass, or powdered cement is added.

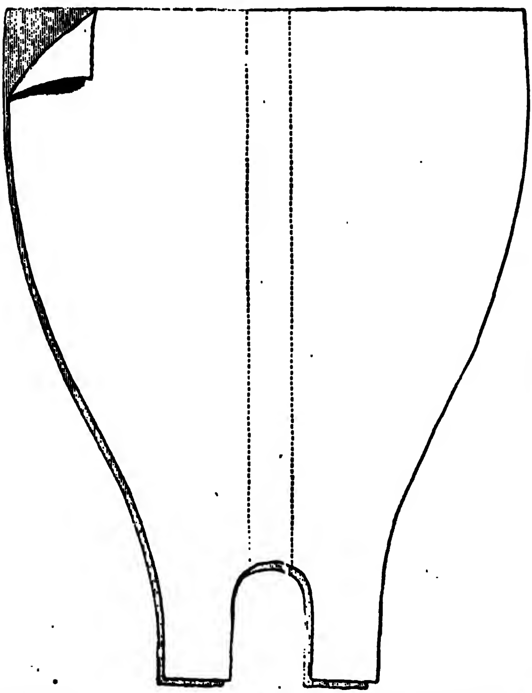
If the **plaster** has been **spoilt** by taking up water from the atmosphere, it can be made **good** again, by **heating** it an open pan until no more steam rises from it.

The **plaster dressing** can be **applied** in various ways.

1. **Strips of bandage** are dipped in the plaster cream, and applied to the limb — previously coated with lard or oil, like the many-tailed bandage of Scultetus (Adelmann) (Fig. 152).

2. Instead of bandages, **old clothes** (woolen stockings, drawers, undervests, etc., or coarse sackcloth), which take up a large quantity of the plaster cream, can be cut up and used to make the dressing (Pirogoff) (Fig. 153).

Fig. 154.



The two pieces of cloth for a Bavarian splint for the leg.

Fig. 155.

Bavarian splint.

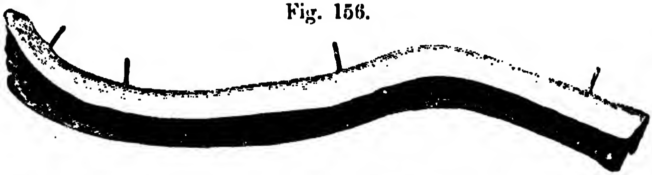
3. The plaster cream is poured between two pieces of linen or cotton cloth sewed together in the middle, and the limb is surrounded with them (**plaster compress, Figs. 154, and 155**). As soon as the

plaster has hardened, the two halves which are joined together by the seam behind, can be opened, and the injured part is left free (removable plaster dressing, Bavarian splint).

4. **Removable plaster splints** can be made of **bundles of hemp, flax, or jute,** dipped in the plaster cream and bound with gauze bandages upon the limb — previously oiled (Beely). These are particularly suited for the fixation of compound fractures under antiseptic treatment.[1])

If it is desired to suspend limbs with splints of this kind, rings or loops of telegraph wire may be included in the plaster between the bundles of hemp (Fig. 156).

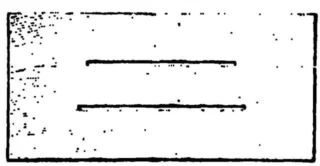
Fig. 156.



Anterior hemp-plaster splint for fractures of the leg (after Beely).

5. Bandages are impregnated with dry plaster of Paris powder, and laid in water shortly before being used. Gauze bandages are best for this purpose.

Fig. 157.



Board for making plaster bandages.

The **gauze bandages** can be most simply **impregnated** by passing the end of the bandage through a slit in an upright board (Fig. 157), in front of which lies a heap of plaster, and rolling the bandage in this heap of plaster.

Plaster of Paris bandages, and the powdered plaster, can be kept in a tin box, and this **board** with a **slit** used to keep them separate (Fig. 158).

With the simple **plaster bandage machine** of Wywodzoff, gauze plaster bandages can be quickly made (Fig. 159).

Cotton batting bandages are used **underneath** the plaster bandage, as the best means for preventing pressure and strangulation; or gauze or flannel bandages are used, wet with an antiseptic fluid, if there are any wounds (Fig. 160).

To make the edges of the plaster dressing smooth and even, the bandage which projects underneath can be turned over like a cuff and secured by a turn of the plaster bandage (Fig. 161) (Ris, Billroth).

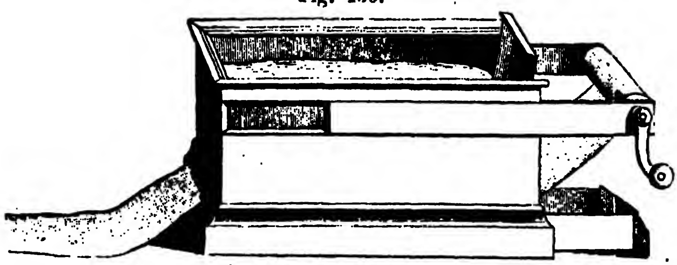
---

[1]) Straw splints are very good for this purpose, but they must first be beaten soft with a hammer, so that the plaster cream can easily penetrate them. (Anschütz.)

Fig. 158.

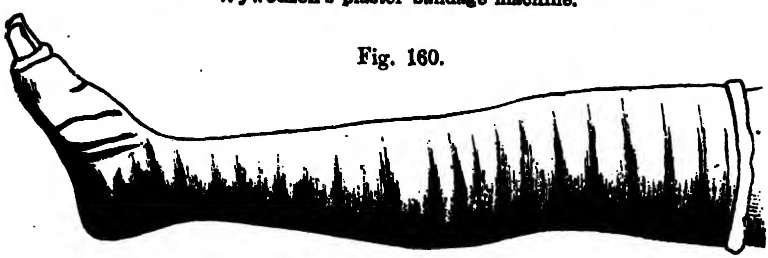
Box for plaster and bandages.

Fig. 159.



Wywodzoff's plaster bandage machine.

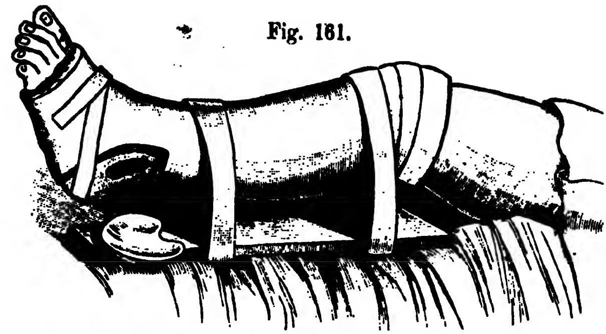
Fig. 160.



Plaster dressing with cotton underneath.

If, finally, it is desired to give the dressing a smooth clean surface, powdered plaster is sprinkled on it and rubbed with wet hands.

Fig. 161.

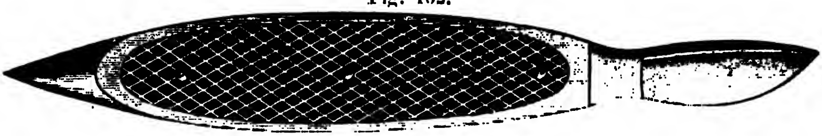


Fenestrated plaster dressing with the edges turned back (Ris).

To make the dressing **water-proof**, it is painted with a brush with a solution of damar-resin in ether (1 to 4) — damar varnish, until saturated.

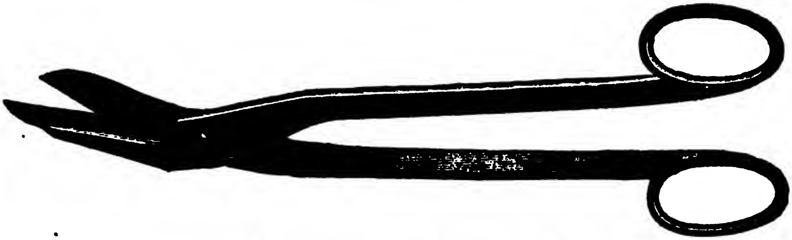
The best method to **remove a plaster dressing** is to make a deep furrow in it with a very short thick knife (Fig. 162), or with a hammer, and then to cut the deeper layers with a strong pair of shears (Fig. 163).

Fig. 162.



Knife for removing plaster dressings.

Fig. 163.



Shears for removing plaster dressings.

5. RE-ENFORCEMENT OF THE PLASTER DRESSING.

To strengthen the plaster dressing, a layer of plaster cream can be spread over the bandages. But this makes it thick and heavy.

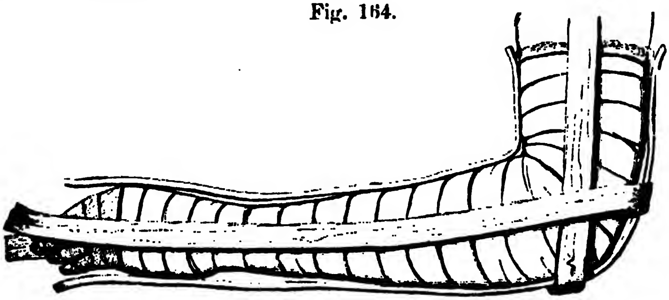
It is more convenient to increase its rigidity by inserting in it wood-sharings (veneering), wooden splints, or iron wire, as it then remains light, and can be more easily removed.

The following will serve as examples:

a. The **re-enforced plaster dressing** for fracture of the forearm and inflammation of the elbow-joint (Figs. 164, and 165).

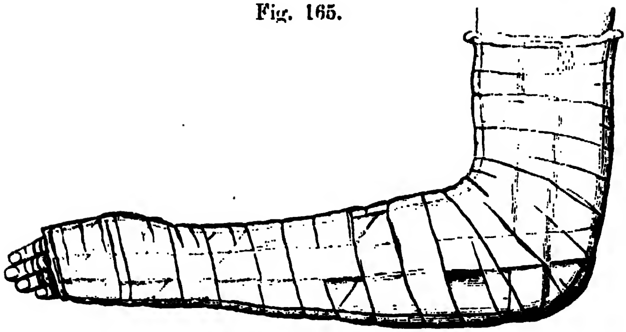
Fig. 164 shows how the wooden strips are placed after the arm has been covered with cotton and a plaster bandage has been applied over it. Fig. 165 shows the finished dressing, after the strips have been surrounded with plaster bandages and their projecting ends cut of with the scissors.

Fig. 164.



Re-enforced plaster dressing for arm with flexed olbow. (Application of the splinting.)

Fig. 165.



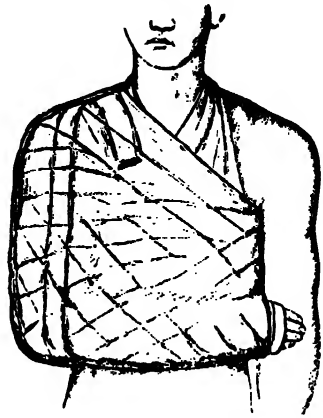
Re-enforced plaster dressing, completed.

b. The **re-enforced plaster dressing** for fractures of the arm, and inflammation of the shoulder joint, is applied as follows. The arm, bent at the elbow and abducted, is carefully bandaged with flannel bandages to a point above the elbow, and above that with cotton batting bandages over the arm and shoulder. The entire arm from the wrist to the shoulder is quickly bandaged with a plaster bandage, and then laid against the body and supported with a sling. The middle of a long wooden strip is placed at the elbow, the two ends are bent upwards along the anterior and posterior surfaces of the arm, and crossed over the shoulder. A second longer strip is laid along the outer side of the arm from the wrist up to the side of the neck

(Fig. 166). The dressing is completed by enclosing the wooden strips, the arm, and the sling with plaster bandages applied like the Desault dressing for fracture of the clavicle (Fig. 167).

Fig. 166.

Fig. 167.



b.

Re-enforced plaster dressing for fractures of the humerus, and inflammation of the shoulder-joint.

a. Application of the wood strips after the arm has been bandaged in plaster, and laid in a sling.

b. Covering and fixation of the entire dressing with plaster bandages.

c. The **re-enforced plaster dressing** for fracture of the thigh, according to Völckers.

To secure complete immobility to the fractured thigh, it is necessary to enclose the pelvis, as well as the entire limb in the stiff dressing.

To accomplish this, the sacrum must first be elevated on a pelvic support (Figs. 168 and 169), so that the bandage can be easily passed around the pelvis above it. An iron rod covered with cotton, against which the perineum of the patient is drawn by an assistant making extension on both feet, provides counter-extension, while another assistant fixes the pelvis with both hands. To support the heels during the application of the dressing, the adjustable heel-rest (Fig. 45) can be employed.

The entire limb must first be wrapped in cotton batting bandages, which are to be firmly bound on with a plaster bandage.

Over this are to be placed four strips of wood — in front, behind, and on both sides (Fig. 170), which are to be held at first by the fingers of assistants, then by a plaster bandage with a few spiral turns (Fig. 171).

Over this are applied four or five wet plaster bandages until the dressing has acquired the necessary firmness, and it can be made still

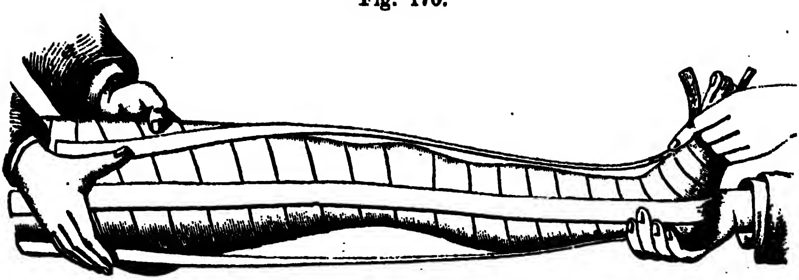
Fig. 168.

Esmarch's pelvic support.

Fig. 169.

Bardeleben's pelvic support.

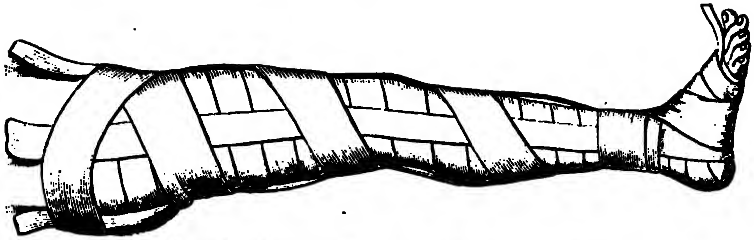
Fig. 170.



Re-enforced plaster dressing according to Völckers. 1.

firmer by applying a thin layer of plaster cream, or by rubbing some powdered plaster on it with wet hands.

Fig. 171.



Re-enforced plaster dressing, according to Völckers. 2.

Finally the projecting ends of the wooden strips are cut off with scissors, and openings made with a sharp knife wherever there are wounds (Fig. 172).

Fig. 172.

Re-enforced plaster dressing, according to Völckers. 3.

If suspension of the limb is desired, in the open treatment of a wound upon the lower side, for instance, a couple of pieces of wood are secured under the splint, and strings are fastened to them and passed over a cross-beam above the bed (Fig. 173).

The pelvis must then be well raised on a cushion, which has an opening, in it for defecation.

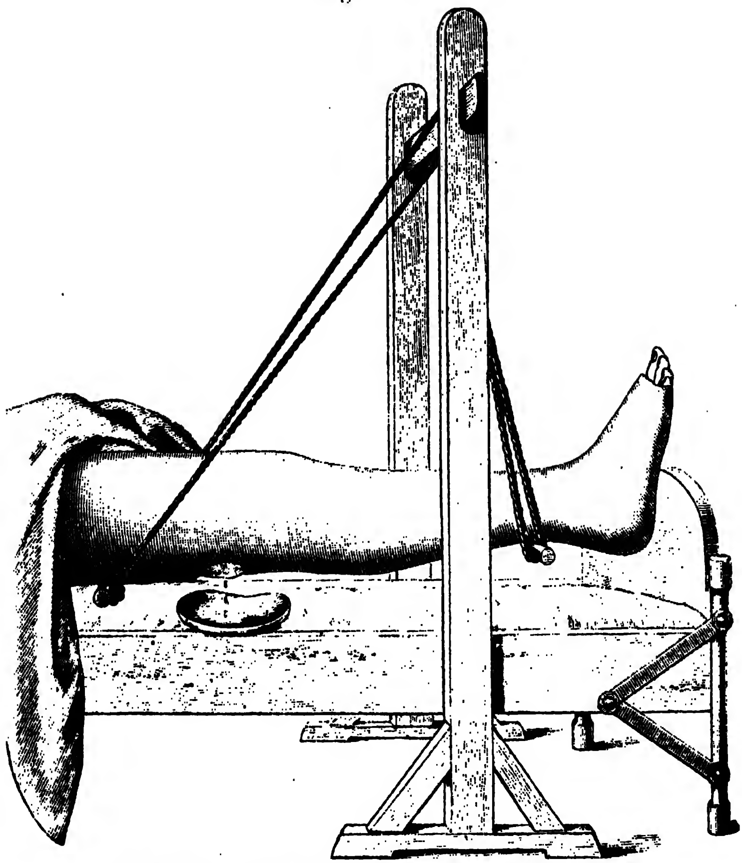
6. FENESTRATED PLASTER DRESSINGS.

Wherever there are wounds, openings must be made in the plaster dressing (fenestration), so that the discharge can have free outlet. The wounds are left uncovered at the time of application, or the openings are cut afterwards with a short knife, or with the scissors.

To locate the point at which the openings are to be made, a ball of cotton, or a wiper is to be laid upon the wound, and this will form a projection upon which the opening can be cut boldly.

To prevent the discharge from penetrating between the plaster dressing and the skin, the edges of the opening must be covered with carbolic cement, or stuffed with cotton soaked in collodion (Fig. 174).

Fig. 173.



Suspension of a plaster dressing of the lower extremity.

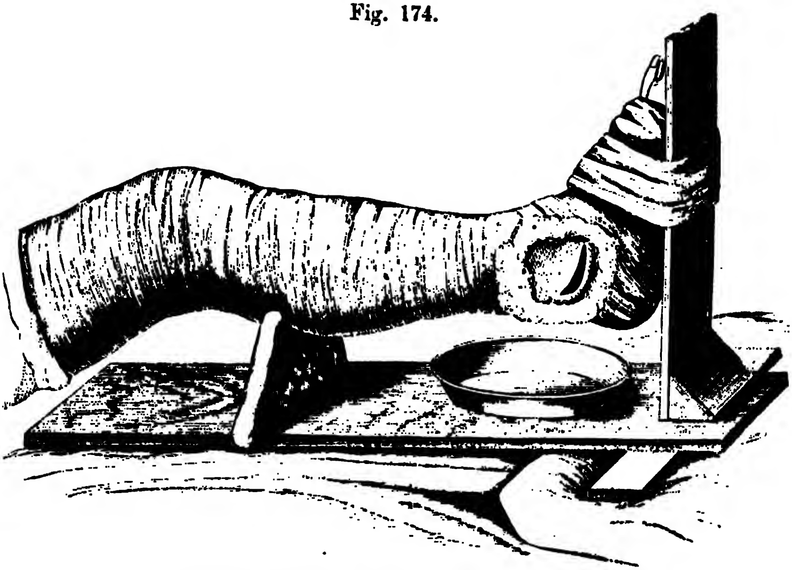
In complicated injuries, and after resection of the elbow-joint a fenestrated plaster dressing can be applied to the arm in a position of flexion to an obtuse angle, and midway between supination and pronation (Figs. 175 and 176).

7. INTERRUPTED PLASTER DRESSINGS.

For severe comminuted fractures of the bones, with extensive injuries of the soft parts, which have already begun to suppurate, the **bridge** or **lath dressing** of Pirogoff can be used with advantage.

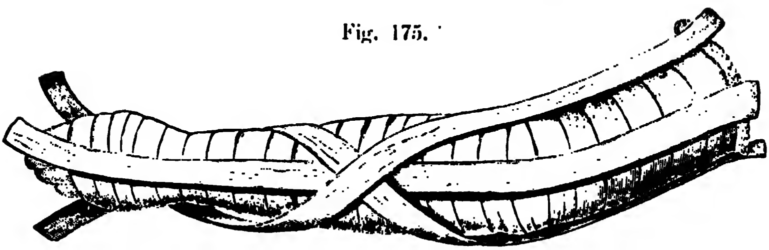
A dressing of this kind for such an injury on the front of the leg will serve as an example (Fig. 177).

Fig. 174.



Fenestrated plaster dressing with cotton edges.

Fig. 175.



Re-enforced plaster dressing for resection of the elbow.
(Application of the wooden splints.)

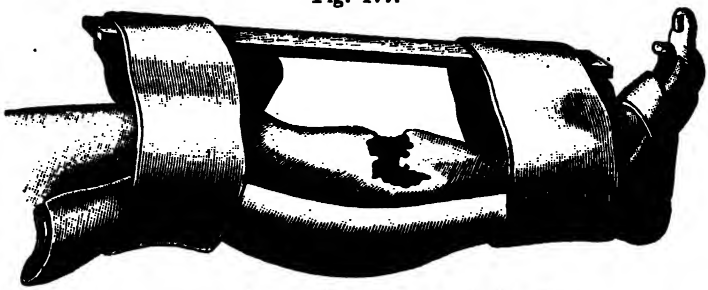
Fig. 176.

Re-enforced fenestrated plaster dressing for resection of the elbow.

After a strong plaster splint, made of coarse sackcloth dipped in plaster cream, has been applied to the calf, two large balls of oakum soaked in plaster cream are laid on the anterior surface of the leg,

and upon these a wooden lath is secured with broad strips of plaster bandage.

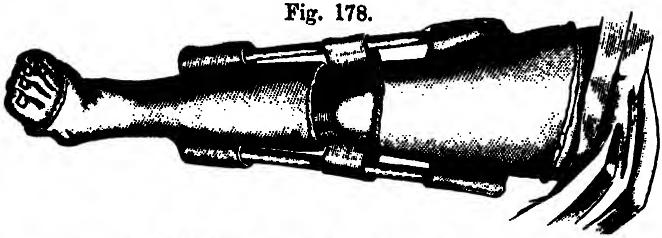
Fig. 177.



Interrupted, or bridge dressing of Pirogoff.

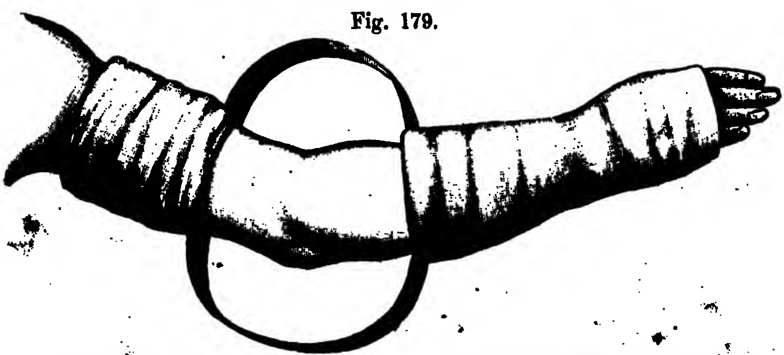
If the wound in the skin is a small one, but there is an injury of a bone or of a joint which renders complete fixation necessary, and yet the injured part must remain open to inspection, a circular plaster dressing can be applied above and below the injured spot, and the two joined by pieces of lath, which are laid upon bunches of oakum soaked with plaster cream, and secured to the plaster dressing by plaster bandages. See for example, Fig. 178.

Fig. 178.



Interrupted dressing with wooden laths for resection of the knee-joint.

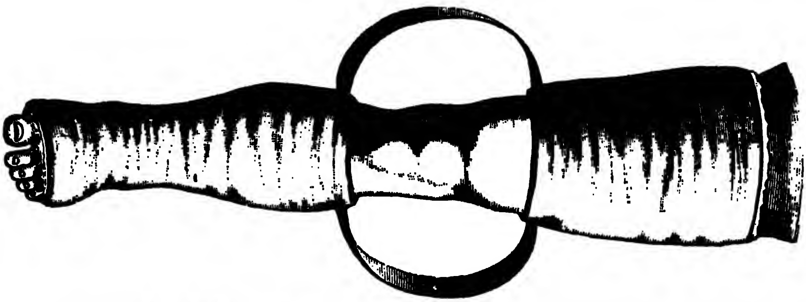
Fig. 179.



Interrupted plaster dressing with stirrups of hoop iron, for injuries in the neighborhood of the elbow.

If however, the injured part must be exposed for a greater extent, so that a large antiseptic dressing can be applied, large **stirrups of hoop iron** can be secured between the two plaster bandages, and these will unite the two parts immovably. See, for example, Figs. 179 and 180.

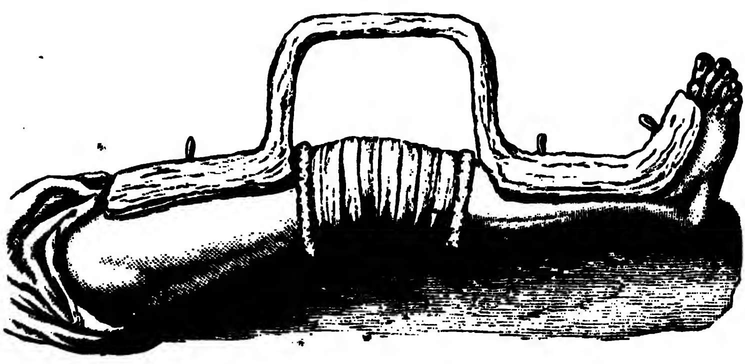
Fig. 180.



Interrupted plaster dressing with stirrups of hoop iron, for injuries in the neighborhood of the knee.

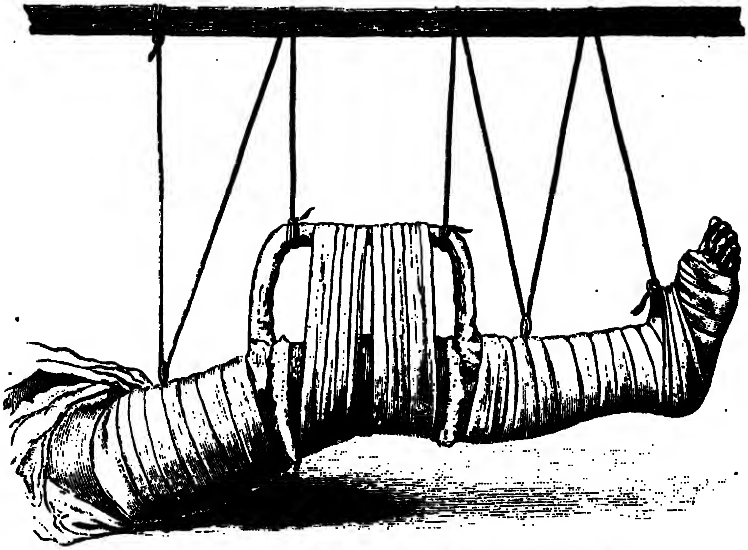
Beely has also suggested a **hemp plaster splint** for resection of the knee, in which the iron hoops are strengthened by strips of hemp impregnated with the plaster cream, so that they cannot yield. It is easy to make, gives the limb secure fixation, and leaves the entire region of the knee so free that an antiseptic dressing of sufficiently large size can be used (Figs. 181 and 182).

Fig. 181.



Beely's hemp plaster splint for resection of the knee.

Fig. 182.



Beely's hemp plaster splint for resection of the knee.

8. PLASTER SPLINT DRESSINGS.

The combination of the plaster dressing with splints and suspension wires, as first proposed by Watson for resection of the knee, is exceedingly convenient for the treatment of injuries and resections of the larger joints.

Watson secured the limb with plaster bandages upon a wooden splint which was narrower in the neighborhood of the knee, and had a long fork-shaped opening at its lower end for the heel (Fig. 136 p. 74).

On the anterior surface of the dressing a strong bent wire is enclosed, by which the entire extremity can be suspended.

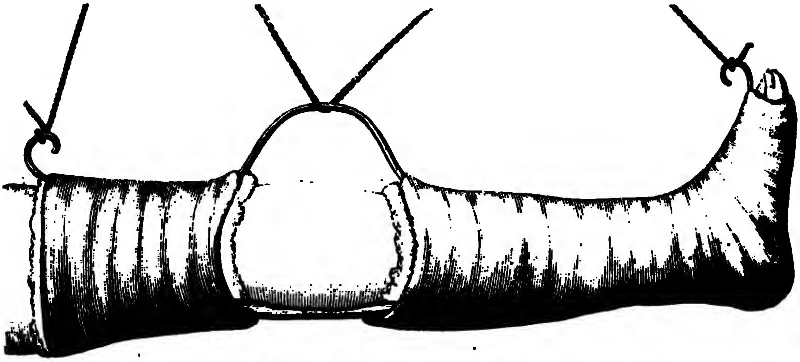
The author has somewhat simplified Watson's wooden splint, and brought the principle of the dressing into use in the treatment of injuries and resections of other joints as well, as the following figures show.

Although these dressings are not entirely suitable for the primary antiseptic treatment of wounds, because a part of the wooden or wire splint is enclosed in the dressing, yet they can be employed with advantage in war quite often, especially in cases where primary antisepsis has failed, or the wounded have come under treatment so late that only open wound treatment or irrigation is possible.

In such cases the plaster suspension splints secure quiet to the shattered limbs, leave the injured part accessible in wide extent to all necessary antiseptic measures, and, in particular, permit the dressings

to be changed without assistance, and without displacement of the fragments of the bone (Fig. 183).

Fig. 183.



Watson's plaster suspension splint for resection of the knee.

These splints are applied as follows:

After the wooden splint has been well cleaned and disinfected, and the narrow bridge, which is intended to support the neighborhood of the knee, has been wrapped with plenty of iodoform gauze, the joint is covered with the antiseptic dressing, and the rest of the limb with cotton, and cotton is laid upon the splint so that it cannot exert injurious pressure at any point (Figs. 184 and 185). [1]

Fig. 184.

The wooden splint, seen from above.

Fig. 185.

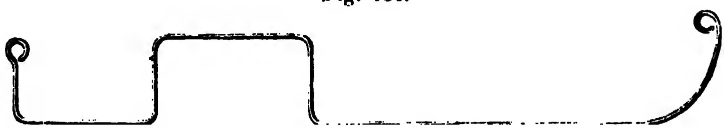
The wooden splint, seen from the side.

Plaster bandages are firmly applied to the leg and thigh, leaving the region of the knee free, and supported only by the narrow wooden bridge. The suspension wire (Fig. 186) is included on the anterior

[1]) I have done away with the fork-shaped lower end which existed in the original Watson's splint, because it appeared to me to be of no particular use, and it made the splint more expensive, and more easily broken.

surface of the leg with the last plaster bandage, and as soon as the plaster hardens the leg is hung by this from a crossbeam over the bed. If there is no wooden splint at hand, a similar one can be improvised

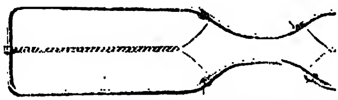
Fig. 186.



The suspension wire.

out of telegraph wire, which can be obtained everywhere in time of war (Fig. 187).

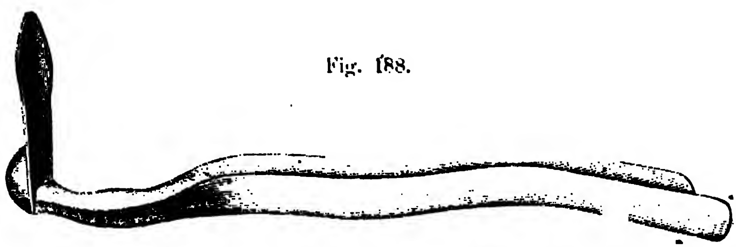
Fig. 187.



Suspension splint of telegraph wire.

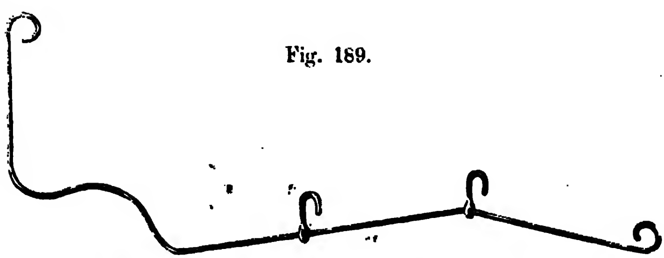
For the **ankle**, the splint and the suspension wire must be altered as shown in the following figures (Figs. 188 to 190).

Fig. 188.



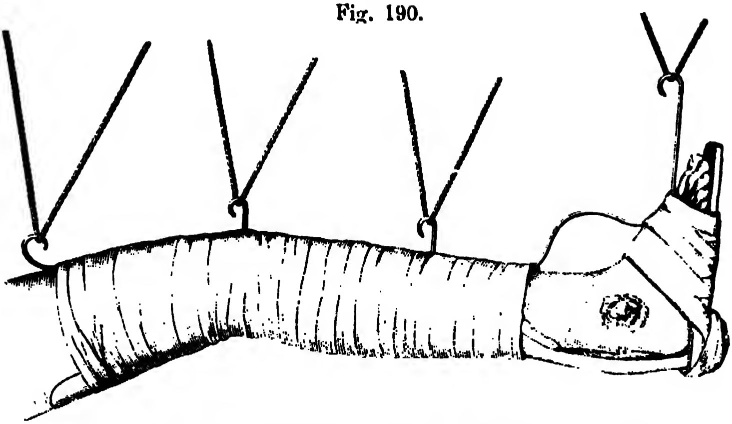
Esmarch's plaster suspension splint for resection of the ankle.

Fig. 189.



Suspension wire for Esmarch's plaster suspension splint for resection of the ankle.

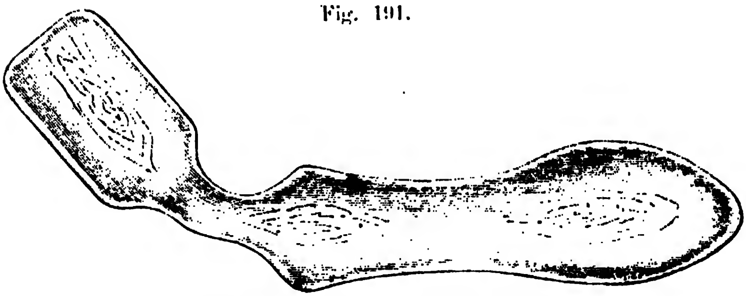
Fig. 190.



Esmarch's plaster suspension splint for resection of the ankle.

For the **elbow-joint**, the splint and wire must be shaped as shown in Figs. 191 to 194.

Fig. 191.

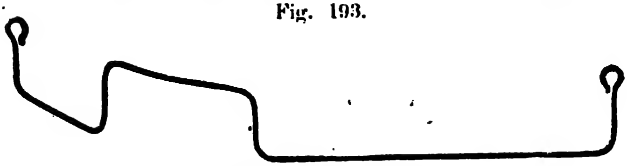


The wooden splint, seen from above.

Fig. 192.

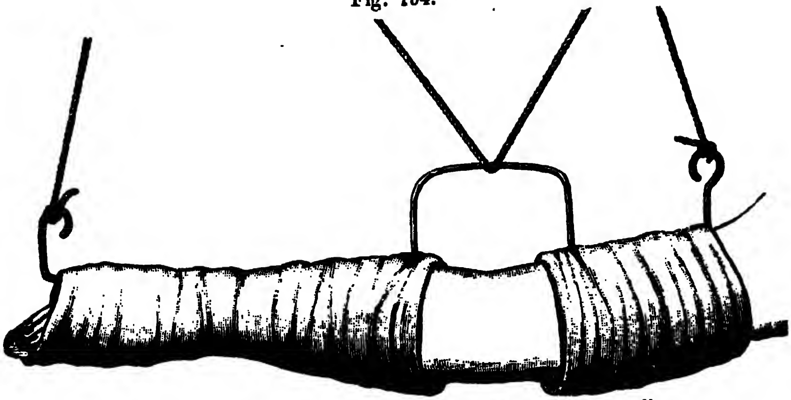
The wooden splint, seen from the side.

Fig. 193.



The suspension wire.

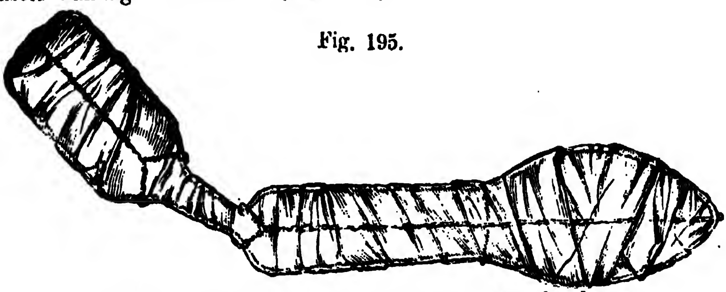
Fig. 194.



Esmarch's plaster suspension splint for resection of the elbow.

If wooden splints are not at hand, the splint can be easily made of telegraph wire. It can be strengthened in this case by wrapping plaster bandages around it (Fig. 195).

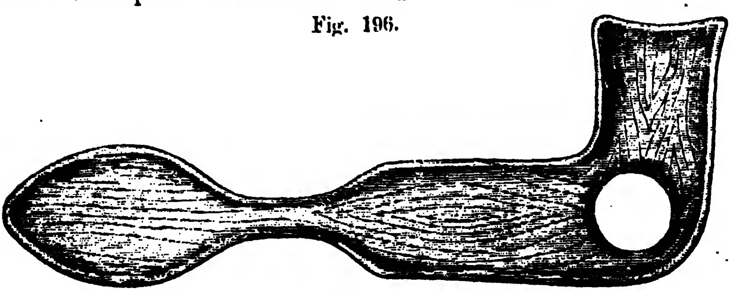
Fig. 195.



Splint of telegraph wire, wrapped with plaster bandages.

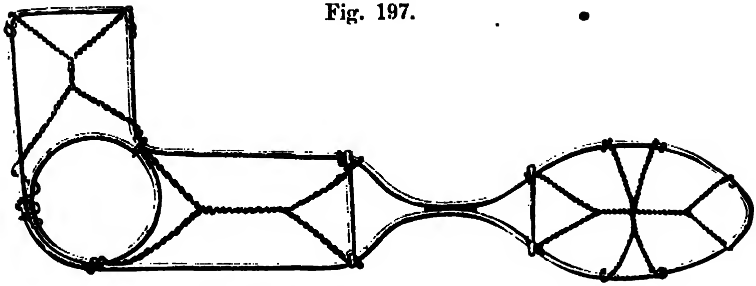
For the **wrist**, the splint must be very narrow at the region of the joint, bent at a right angle at the elbow, and provided with an opening for the internal condyle. The shape of the wire and the method of suspension are shown in Figs. 196 to 199.

Fig. 196.



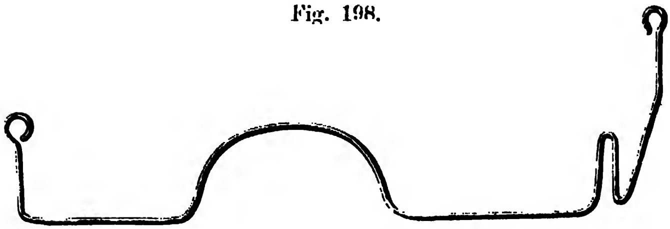
Esmarch's plaster suspension splint for resection of the wrist.

Fig. 197.



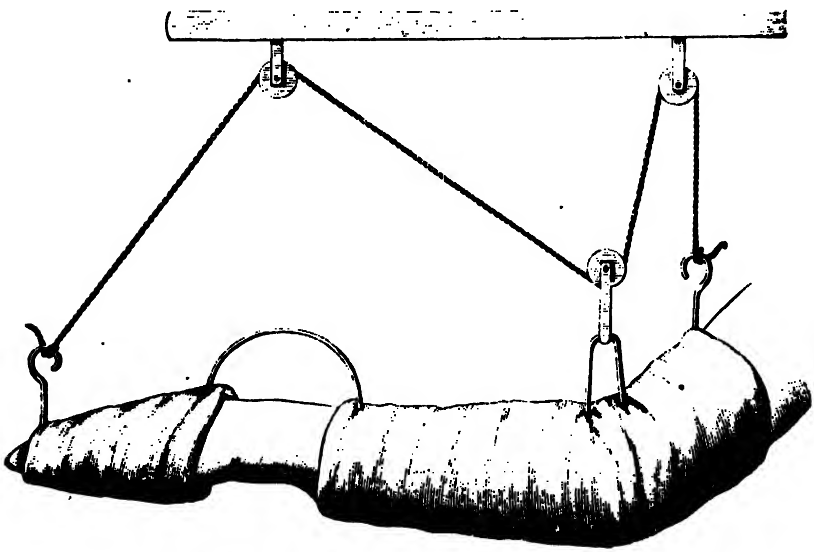
Suspension splint of telegraph wire.

Fig. 198.



Suspension wire.

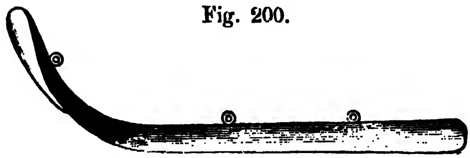
Fig. 199.



Esmarch's plaster suspension splint for resection of the wrist.

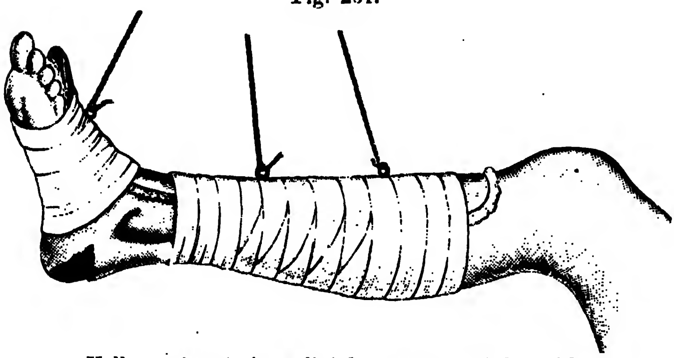
Volkmann's* wooden anterior splint (Fig. 200), secured with plaster or wet gauze bandages to the foot and leg (Fig. 201), gives good fixation to the resected ankle joint.

Fig. 200.



Volkmann's wooden anterior splint for resection of the ankle.

Fig. 201.

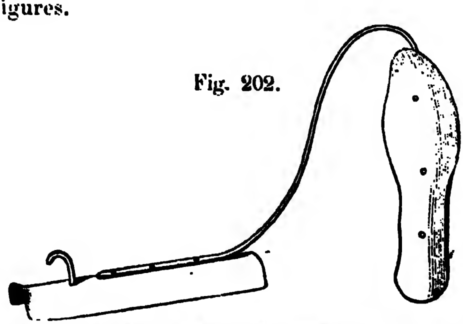


Volkmann's anterior splint for resection of the ankle.

NB. The plaster dressing should have been represented in this figure and the following (Fig. 203), as applied up to a point above the knee.

But if it is desirable to have the entire region of the wound free, in order to apply a completely antiseptic dressing, the two parts of the splint must be joined by a strong wire stirrup, as is shown in the following figures.

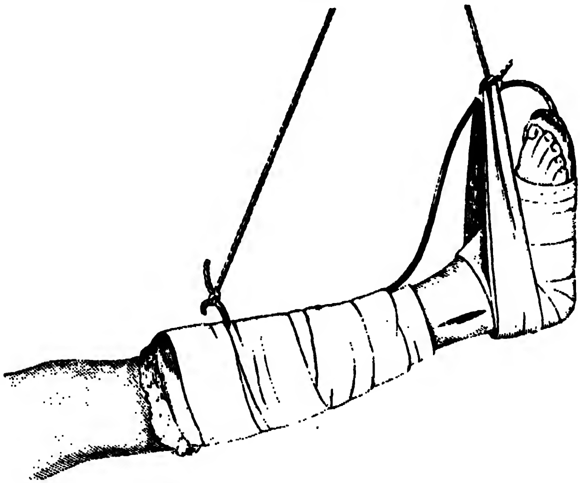
Fig. 202.



Esmarch's iron stirrup splint for resection of the ankle.

The **stirrup splint** (Fig. 202), consists of a sole-piece, and a small anterior splint for the leg, both made of sheet iron and connected by an anterior wire stirrup. The foot is secured to the foot-piece by adhesive plaster and plaster bandages, and the leg secured to the anterior splint in the same way. The heel can be supported, in addition, by a triangular cloth (Fig. 203).

Fig. 203.



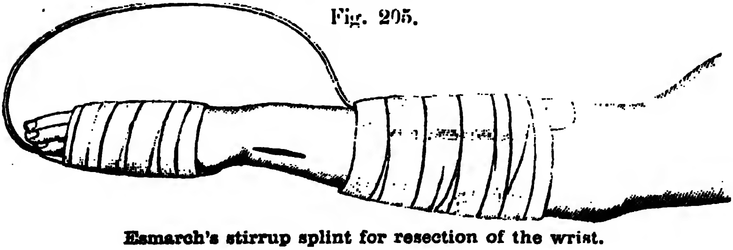
Esmarch's stirrup splint for resection of the ankle.

My **stirrup splint** for resection of the wrist (Figs. 204 and 205) was made for a similar purpose. It consists of a splint of sheet iron

Fig. 204.

Esmarch's stirrup splint for resection of the wrist.

Fig. 205.

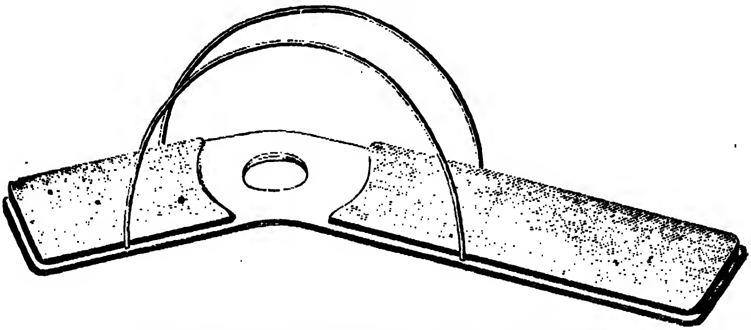


Esmarch's stirrup splint for resection of the wrist.

for the hand, and another for the dorsal surface of the forearm, connected by a stirrup of strong iron wire.

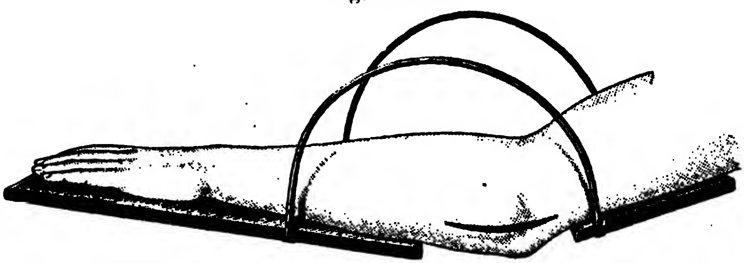
My **double splint** for resection of the elbow joint, which I made in 1866 for the wounded in Langensalza, when I went thither from Berlin to visit Stromeyer, is very useful for antiseptic dressings, and can easily be made by any carpenter (Figs. 206 to 208).

Fig. 206.



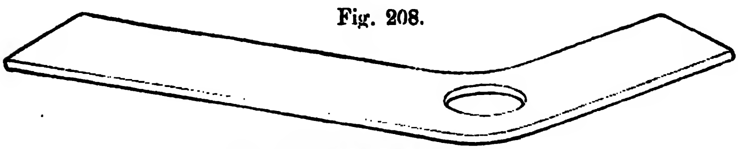
Esmarch's double splint for resection of the elbow.

Fig. 207.



The upper padded stirrup splint, with the arm raised from the lower flat wooden splint, which gives security to the apparatus.

Fig. 208.



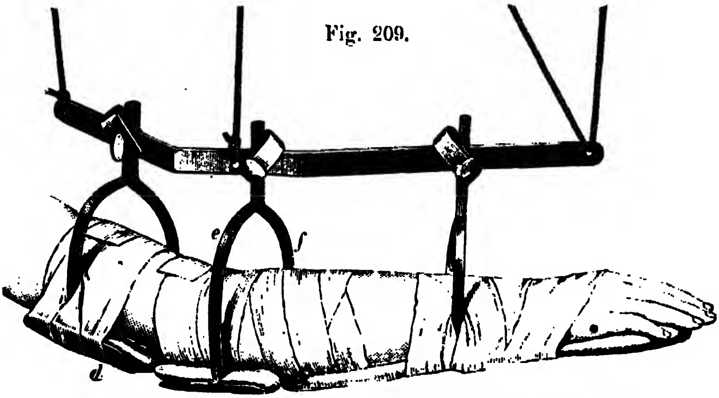
The lower flat wooden splint.

In changing the dressing, the interrupted stirrup splint upon which the arm rests, and which is padded antiseptically, is lifted from the lower splint, so that the latter can be cleaned and disinfected.

Somewhat more complicated, but exceedingly convenient for cases of extensive injury of the bones and soft parts, because every part of

the splint can be separately removed, is my **iron sectional suspension splint** for resection of the elbow joint (Figs. 209 to 213).

Fig. 209.

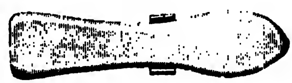


Esmarch's sectional suspension splint for resection of the elbow.

Fig. 210.

Suspension rod, seen from above.

Fig. 211.

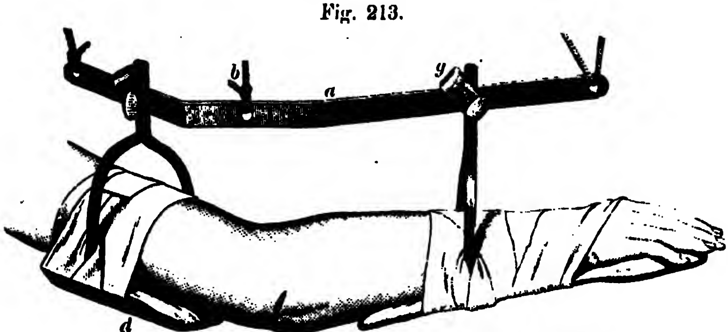


Splint for the hand and forearm.

Fig. 212.

Middle splint.

Fig. 213.



The middle splint removed for renewal of the dressing.

It consists of three hinged splints, the movable arms of each being secured by screw clamps to a bent suspension rod (Fig. 210).

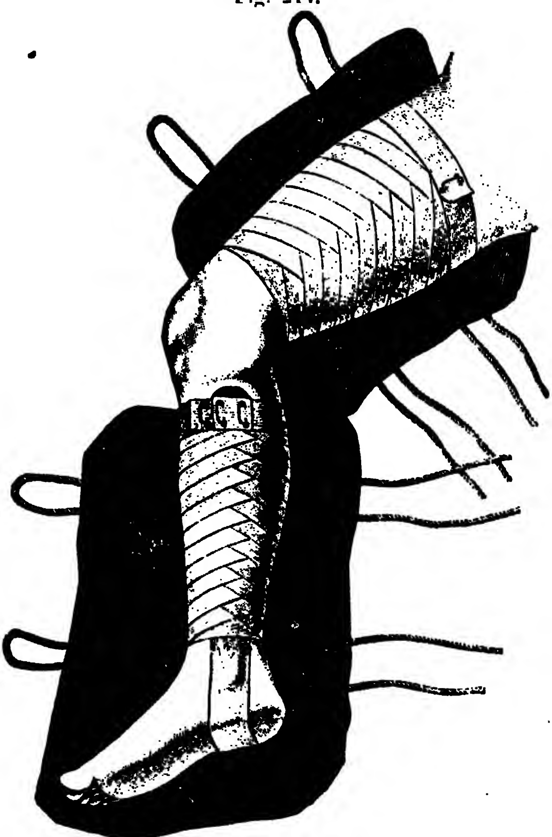
The arm rests safely on the two end splints, if it is necessary to remove the middle piece (Fig. 212) to renew the dressing (Fig. 213).

MISCELLANEOUS APPARATUS.

Various special forms of apparatus are employed to give comfortable and secure position to the injured limbs — alone, or combined with other dressings.

They lessen the sufferings of the patient and the labor of the surgeon, especially in extensive and severe injuries.

Fig. 214.



Pott's lateral position.

As they are, for the most part, heavy and bulky, they are less suited for transport than for treatment in hospital.

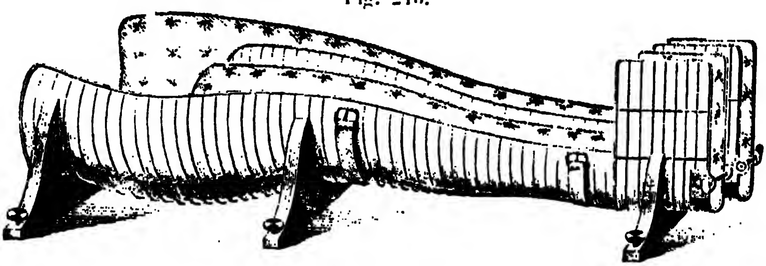
For military practice, those are most useful which are not too heavy, too complicated, and too expensive, and which can be easily made from drawings by any mechanic.

If other means of treatment for severe injuries of the lower extremity are not at hand, Pott's **lateral position** is employed as the simplest temporary position method (Fig. 124). This method consists in laying the limb upon cushions, with the knee and hip partly flexed, and resting upon its outer side, so that the muscles are relaxed and disturbance of the circulation is avoided. The wounds are dressed by using the many-tailed bandage of Scultetus.

If the patient must be moved in this position, cords are passed under the cushions and the latter tied around the limb.

For the transportation of severely wounded persons for greater distances, especially if both extremities are injured, the **wire-breeches** of Bonnet (Fig. 215) are excellent — for they form a padded wire

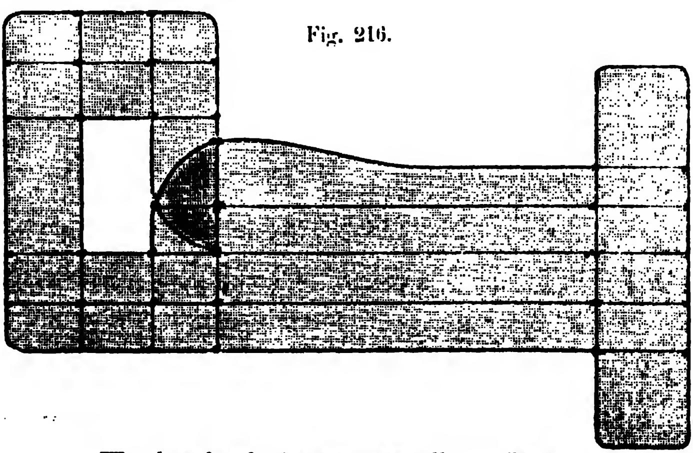
Fig. 215.



Bonnet's wire breeches.

basket in which the broken limbs rest very well. Flaps can easily be made in them so that the wounds can be dressed without disturbing

Fig. 216.



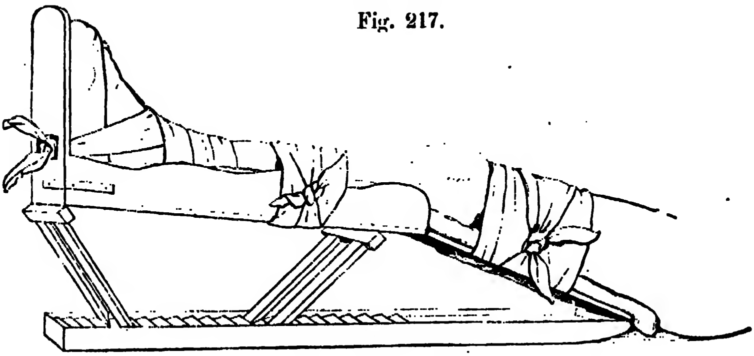
Wire breeches for transport, according to Esmarch.

the position of the limb. There is a contrivance for making extension at the foot end. But these splints are expensive, and require too much space for military practice.

Wire breeches, however, can be made from the commercial wire netting (wire sieve material) which are lighter than Bonnet's and are so flexible that they can be spread out flat, and easily carried to the field in considerable quantity (Fig. 216).

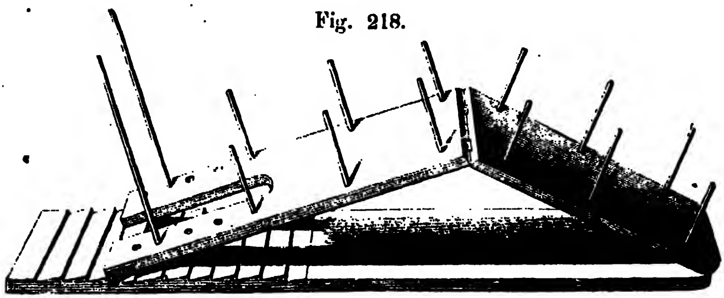
The **double inclined plane** (planum inclinatum duplex) is suitable for use in hospital, whether made like a Petit's fracture-box (as in Fig. 217); or simpler (as in Fig. 218) — made of a few boards,

Fig. 217.



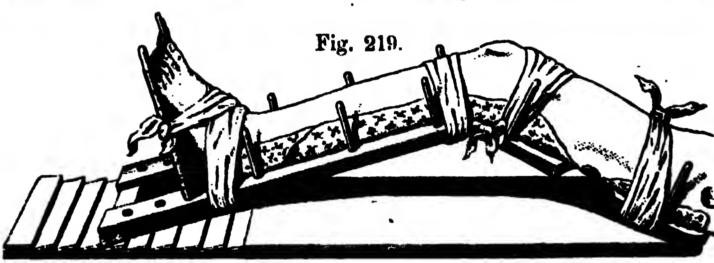
Double inclined plane.

Fig. 218.



Esmarch's double inclined plane.

Fig. 219.

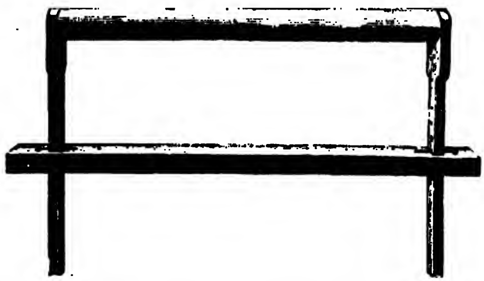


Esmarch's double inclined plane.

and furnished with wooden pegs at the sides by which the edges of the quilted horsehair mattress upon which the leg rests are pressed against the latter. If there is a wound on the back part of the limb, a piece can be sawed out of the board at that spot (Fig. 219). To support the foot, there are two longer pegs, between which a linen bandage can be stretched in figure-of-eight turns.

A useful double inclined plane can also be made for both legs by Dobson's **wooden knee support** (Fig. 220) which is placed under the mattress beneath the knees.

Fig. 220.



Dobson's knee support, for raising the mattress.

The **double abduction splint** of von Renz (Fig. 221) is particularly suited to those compound fractures of the thigh in which the

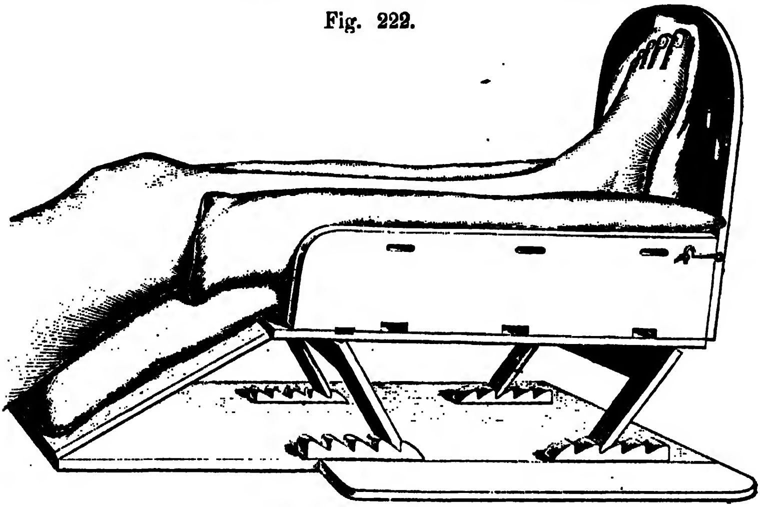
Fig. 221.

Double abduction splint of von Renz.

upper fragment is in a position of strong abduction. As this splint can be easily made of boards by any carpenter, it would prove useful in small places distant from the large cities — where the surgeon must rely upon himself. Flaps can be made wherever there are wounds. The small round cushion which closes the opening in the perineal region is removed for defecation.

For compound fractures of the leg, the **fracture-box** of Petit, introduced into Germany by Heister (Fig. 222) was probably the most commonly employed apparatus before the time of antisepsis.

Fig. 222.

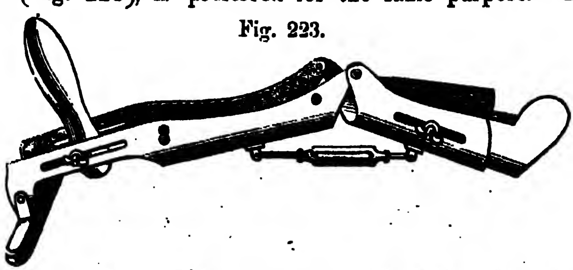


Petit's (Heister's) fracture box.

The leg is held in the box between movable side flaps and straw cushions, and in renewing the dressing each side of the leg can be exposed in turn, without changing its position. The angular position of the knee can be altered by means of the movable legs, as may be desired (compare Stromeyer's „Maximen", page 526).

In England the Mac Intyre **leg splint** of sheet iron, as improved by Liston (Fig. 223), is preferred for the same purpose. This splint

Fig. 223.



Mac Intyre's splint, improved by Liston, for compound fractures of the leg.

has a movable foot-piece, adjustable in various directions, and the angular position of the knee can be very gradually altered by a screw at the back. The transverse piece at the lower end gives the splint security of position. The length of the thigh piece can be altered at will.

The **leg splint** introduced by Scheuer has the advantage that it can be made very quickly of a few wooden laths.

Fig. 224.

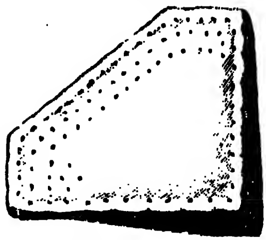
Scheuer's leg splint.

The slightly concave splints with foot supports (Fig. 144) have of late been preferred to fracture-boxes by most surgeons.

In compound fractures of the arm, and injuries of the shoulder-joint, Stromeyer's **cushion** is very useful.

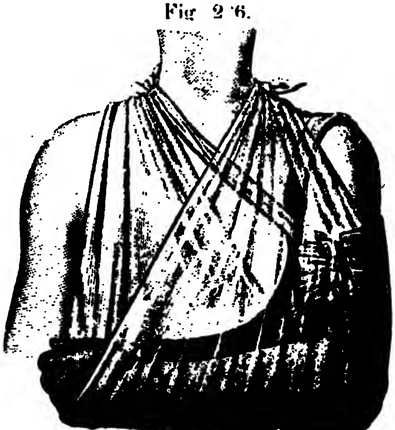
This is a soft triangular cushion with rounded corners, stuffed with horse-hair and covered with waterproof material (Fig. 225). One of the rounded corners is laid in the axilla and secured by safety-pins in front and behind to a strip of bandage, which is brought over the sound shoulder. The arm is then laid against the cushion in flexion, and both are supported by a sling (Fig. 226).

Fig. 225.



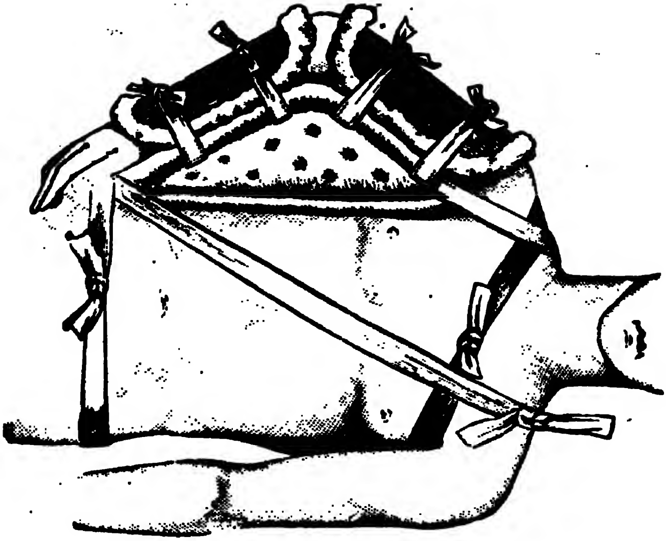
Stromeyer's cushion.

Fig. 226.



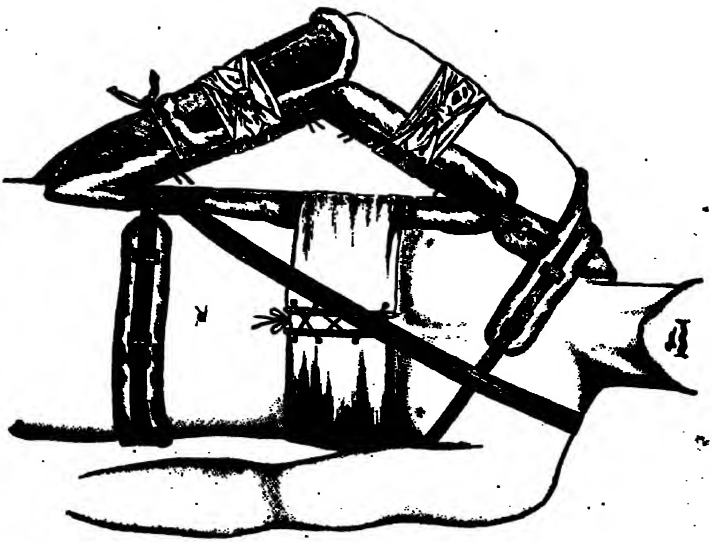
Use of Stromeyer's cushion in a compound fracture of the humerus.
(The sling is drawn as if it were transparent.)

Fig. 227.



Mi' ıldorpf'

Fig. 228.



Middeldorpf's triangle.

This secures a quiet position for the arm by preventing the movements of respiration from being conducted to the fractured point.

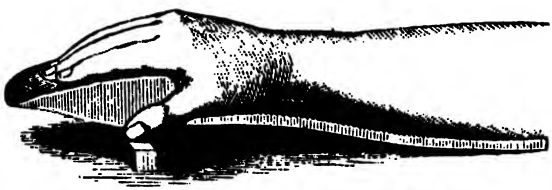
The wounds are dressed with the many-tailed bandage of Scultetus, by throwing back the outer layer of the sling.

In fractures of the upper end of the humerus, with obstinate abduction of the upper fragment, the entire upper part of the arm can be placed in abduction by means of Middeldorpf's **triangle**, a triangular wedge shaped cushion (Fig. 227), or a double inclined plane made of three boards (Fig. 228), the longest side of which is secured to the side of the body by belts or cloths, while the arm, bent at an obtuse angle, is laid upon the two short sides and bound fast to them.

The entire arm must be carefully bandaged from below upwards, for its dependent position makes it very liable to oedema.

Fig. 229.

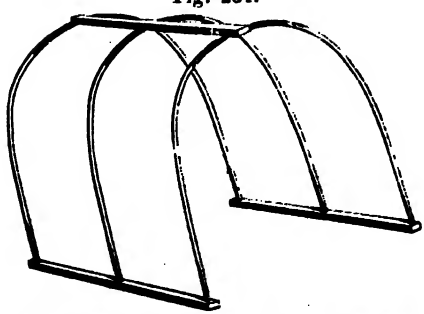
Fig. 230.



Lister's splint for resection of the wrist.

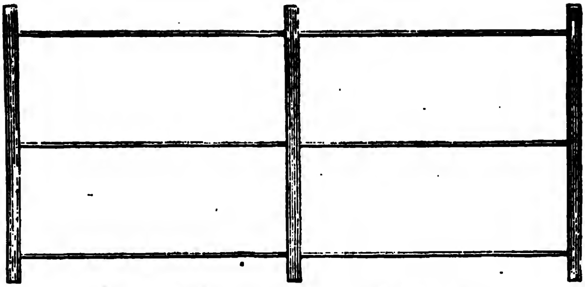
The splint for resection of the wrist introduced by Lister, made of wood covered with soft leather (Figs. 229, and 230) is also a posi-

Fig. 231.



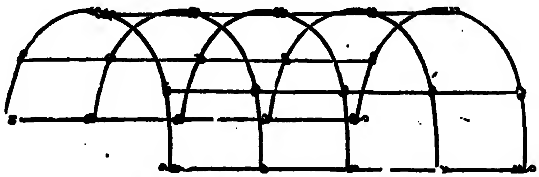
Cradle of three copper wires and two wooden rods.

Fig. 232.



The same, flattened out for transportation.

Fig. 233.



Cradle made of telegraph wire.

tion apparatus, upon which the hand and fingers rest very comfortably. It is particularly suited to the latter part of the after-treatment, if frequent passive and active movement of the fingers is to be undertaken.

For **protection** against any accidental contact, and to remove the weight of the bed-clothes, a **cradle** of bent wire and wooden rods, or of barrel-hoops, is placed over the injured part and the position apparatus (Figs. 231, to 233).

APPARATUS FOR MOVING THE INJURED.

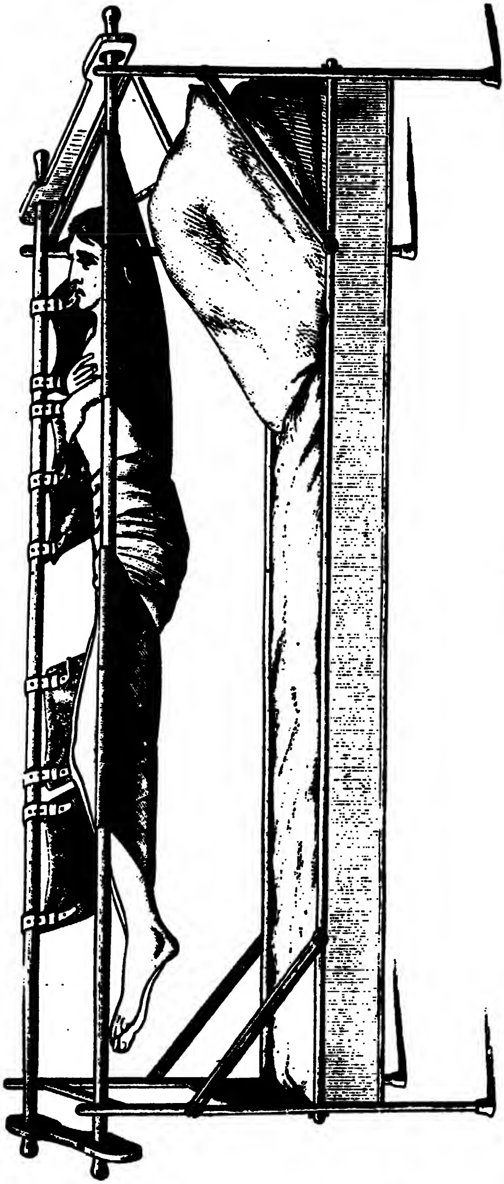
In permanent well-furnished hospitals, special apparatus, which is often complicated and expensive, is used to move severely injured patients in order to renew the bed-linen, to cleanse the back, to wash and protect from bedsores, and to allow defecation without pain and injury to the shattered limbs by movement.

In war-time, these must often be quickly **improvised**, and with limited means.

The **stretcher** represented in Fig. 234 recommends itself by its simplicity and convenience.

Four wide strips of sailcloth are provided with a hem on one side and with straps and buckles on the other, two of these are slipped under the trunk, and two under the legs of the patient, a litter pole is pushed through the hem on one side of the strips, and another is

Fig. 234.

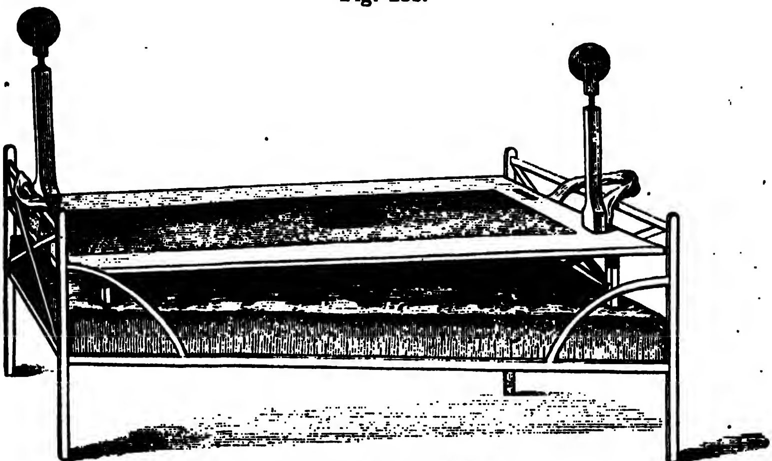


Stretcher.

strapped on the other side; the two poles are lifted together, and rest on the head and foot of the bed, being held apart by two cross-pieces of wood with holes in them, through which the ends of the poles are passed.

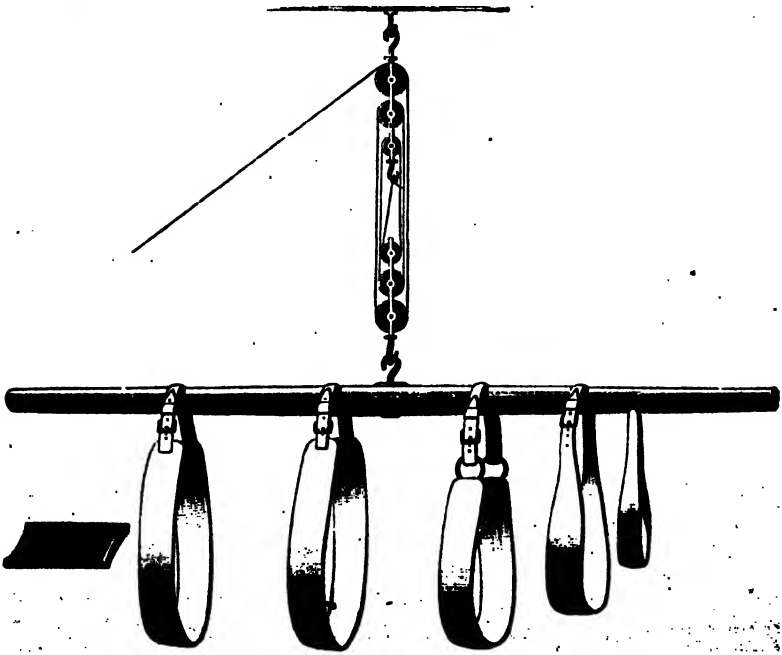
The wounded part, in this case the hip, remains free, so that the dressing can be easily changed.

Fig. 235.



Volkmann's lifting frame.

Fig. 236.



Von Siebold's lifting apparatus.

Dr. Laub, of Copenhagen has introduced a similar apparatus.

The **lifting-frame** introduced by Volkmann is also useful for this purpose (Fig. 235).

The sailcloth spread over the wooden frame has an opening in the center for defecation. By two handles of belting attached to the ends, the patient is lifted with the frame, and supported in this position by the folding wooden feet. Pulleys for treatment by extension are attached to the frame itself.

The apparatus invented by Siebold is also to be recommended, on account of its simplicity (Fig. 236).

The strong pole is easily hoisted by a pulley fastened to the ceiling of the room. The buckled bands in which the patient is suspended press close against the body when its weight comes upon them, and if this is in any place undesirable, a board, shown on the left, must be inserted to hold the band open.

Fig. 237.

Adjustable back-board.

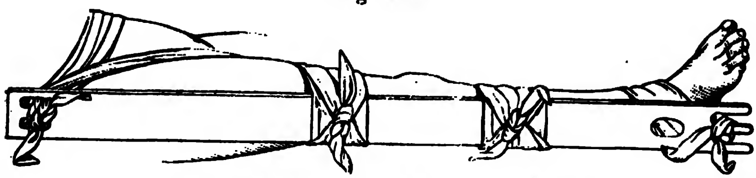
The **adjustable back-board,** which is placed behind the pillow, and permits the patient to assume various positions, is very comfortable for the severely sick, or wounded. They can be easily and cheaply made in the form represented in Fig. 237.

EXTENSION DRESSINGS.

Dressings which effect a continous extension are used with the greatest advantage, both in simple and compound fractures, and in inflammation of joints.

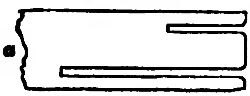
The Desault-Liston splint (Fig. 238), with the lower end as improved by Haynes Walton (Fig. 239), is one of the less perfect forms of apparatus, but it is simple, and always useful for the first emergency dressing and for transport. The foot is secured to the lower end by a handkerchief, while a second, passing over the perineum, makes counter-extension, and a third (girdle-cloth) secures the upper end of the splint to the body. A fourth and fifth handkerchief fasten the thigh and leg laterally to the splint.

Fig. 238.



Desault-Liston splint for fracture of the thigh.

Fig. 239.

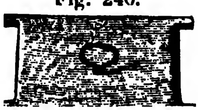


Improved form of the lower end of the Liston splint according to Haynes Walton.

The treatment by extension first came into general use after Crosby had shown that a long continued extension could be made endurable by properly distributing the attachment over a large area of the surface of the skin.

Crosby's adhesive plaster extension consists of a strong broad plaster strip which is applied along both sides of the leg, as high as the fractured point in the thigh. It holds a small foot-piece (Fig. 240), provided with a ring, against the sole of the foot near the heel, and is itself secured by another strip of adhesive plaster which surrounds the leg in spiral turns, pressing the first strip firmly against it (Fig. 240).

Fig. 240.



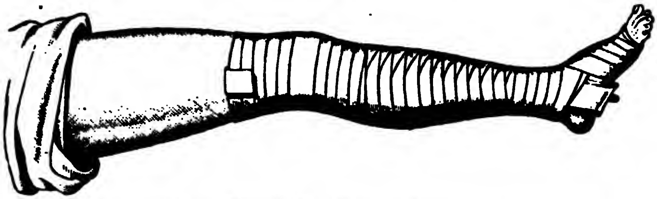
Foot-piece.

Fig. 241.

Crosby's adhesive plaster extension.

The entire limb is then firmly bandaged from the toe nearly to the upper end of the first strip of plaster, which is turned down over the upper edge of the completed bandage (Fig. 242).

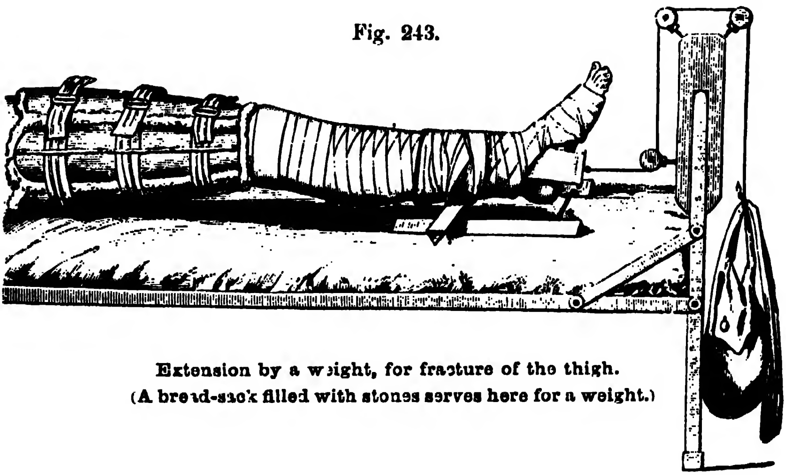
Fig. 242.



Crosby's adhesive plaster extension. 2.

A weight is then attached to the ring in the foot-piece by a string which passes over a pulley, and the leg is thus drawn towards the foot of the bed (Fig. 243).

Fig. 243.



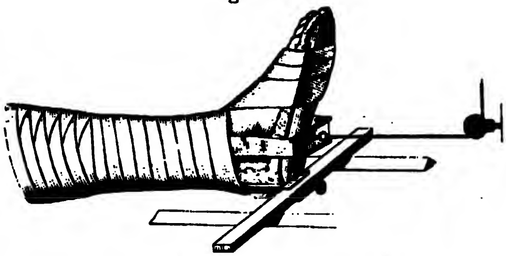
Extension by a weight, for fracture of the thigh.
(A bread-sack filled with stones serves here for a weight.)

If the leg were now left without any other support, it would sink into the mattress, and the action of the weight would be entirely or partly counteracted by friction. The lateral displacement of the foot would also cause rotation of the fragments of the bone.

To prevent these faults, the leg can be placed on the **sliding apparatus** of Volkmann (Fig. 244), a short, iron, concave splint, with an opening for the heel, to which is attached a foot-piece, and also a narrow cross-piece underneath, which rests and slides on two smooth angular pieces of wood.

In the absence of this apparatus, an angular cross-piece can be secured to the back of the leg by a few turns of plaster of Paris bandage, which are also carried around the foot, and this can be made to slide on two angular pieces of wood which are held parallel to eachother by iron wire (Fig. 243).

Fig. 244.

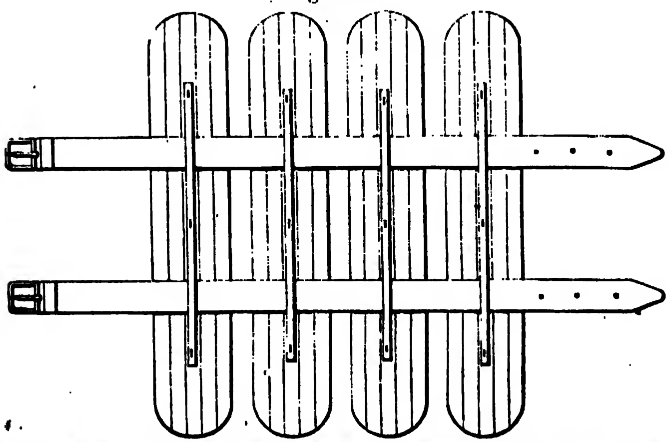


Volkmann's sliding apparatus.

Counter-extension is made by a padded band passing over the perineum, or by a thick rubber tube covered with cotton, and fastened to the head of the bed by hooks, or by the weight of the body, — the foot of the bed being raised by blocks of wood or by bricks.

To prevent lateral movement of the fragments, the thigh is surrounded with short splints, **Bell's splints** (see Fig. 129), for example, or four of Gooch's **coaptation splints**, which are secured by straps and buckles (Fig. 245).

Fig. 245.

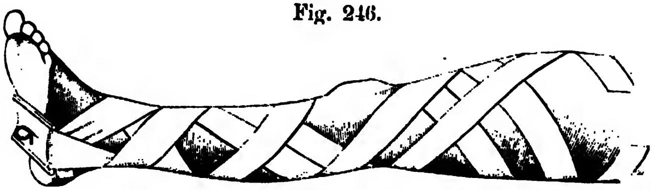


Gooch's coaptation splints, with straps and buckles, for fracture of the thigh.

As extension by weights, or by suspension, is not suited for use in transportation from the field of battle, the author has suggested for this purpose an **extension by rubber rings**, applied as follows: To secure the foot-piece under the sole, in the absence of Crosby's adhesive plaster, two wet bandages can be employed, each twice as long as the entire leg, with a split in the middle through which the ring of the foot piece is passed. Thus four strips are attached to the foot piece, two of which are to be carried in front of the leg, and two

behind, and wound around it in spiral turns (Fig. 246). If the entire leg is carefully bandaged over these strips with a dry bandage, up to the point of fracture, considerable extension can be maintained upon

Fig. 246.



The foot-piece secured with strips of wet bandage.

the foot-piece for weeks without causing the bandages to slip. If there is any starch or flour at hand, the strips can be made to adhere much more strongly by spreading it upon the wet bandages.

Rubber rings, such as are to be had anywhere in the shops, are employed for the elastic extension; or if they are not to be had, pieces of **rubber tubing**, in the ends of which are tied **wooden knobs** with hooks (Figs. 247 and 248).

Fig. 247.

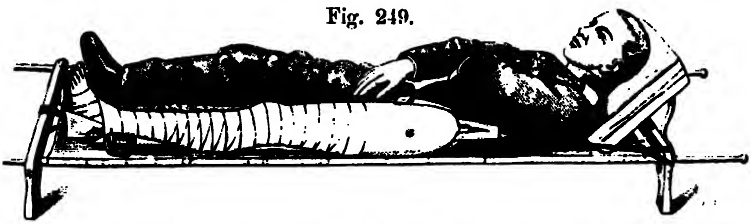
Knob and hook for the rubber tube.

Fig. 248

Rubber tube with knobs and hooks for elastic extension.

For the transportation of the injured, the elastic rings can be fastened to the upper and lower ends of the stretcher (Fig. 249), and

Fig. 249.



Esmarch's stretcher extension dressing for transportation of gunshot fracture of the thigh.

for a **counter extending band** the **belt** of the injured man is employed — or his trousers, cut open on the outer side as high as the pelvis, and on the inner side to the middle of the thigh, and rolled up to the perineum. To prevent lateral movements of the leg, the **boot** can be used as a **foot-support**. For this purpose, the boot is cut up the middle line in front, from the situation of the metatarso-phalangeal joint, and a curved cut is carried from the same point to the anterior edge

of the heel; the upper end of the boot-leg is then wound on a bunch of twigs, a narrow wooden splint, or the sidearms of the injured man, and tied with string at both ends (Fig. 250).

Fig. 250.

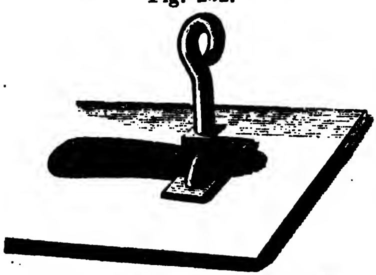
Foot support made of a regulation army boot.

A jointed splint of five pieces of wood, with a sort of ferule of tin on the end, so that the parts can be put together by sticking the end of one into the tin ferule of the next (Fig. 251), can also be

Fig. 251.

Wooden splint with tin ferule.

Fig. 252.

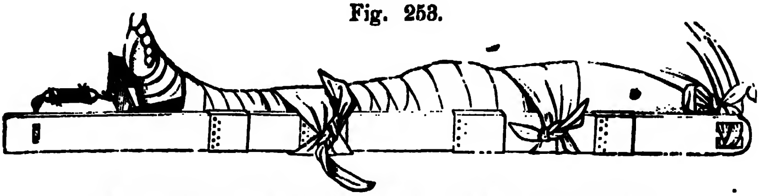


Removable hook for the jointed extension splint.

employed for the elastic extension. When in use, an iron hook (Fig. 252) is attached to the lower end, and the extension ring is fastened to this. On the upper end of the splint are two slits to which both the pelvic girdle and the perineal band must be secured — the perineal band by the second rubber ring. If it is not necessary to use the trousers of the injured man as a counter-extending band, one of the

trouser-legs can be folded up, and placed between the limb and the splint for padding. The splint, taken apart, with its hooks and two rubber rings, occupies so little space that several of them can be easily carried to the field of battle in a dressing-knapsack (Fig. 253).

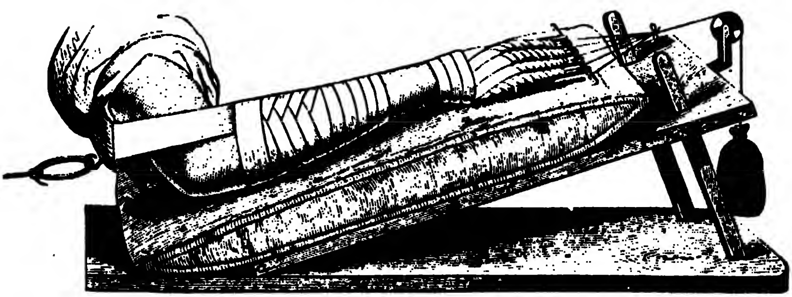
Fig. 253.



Esmarch's jointed splint for elastic extension of the thigh.

For **extension** of the **wrist** in inflammation, and in the latter part of the after-treatment of resection, loops of adhesive plaster of equal length are secured to all the fingers by the hand and finger bandage (see Fig. 78); and a small wooden rod is passed through the loops. Small strings, acting over a pulley, connect a weight with this rod. Counter-extension is obtained by a larger loop of adhesive plaster which is made to adhere to both surfaces of the forearm and fastened to the head of the bed by a rubber ring. The arm rests upon an inclined plane (Fig. 254).

Fig. 254.



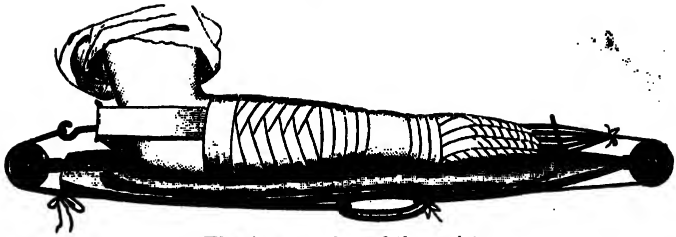
Extension of the wrist by weight and pulley.

If it is desirable to have the patient move about, elastic extension may be employed, instead of the weight, acting by a rubber ring put on the stretch under the splint (Fig. 255).

Sayre's **adhesive plaster dressing** for fracture of the clavicle is an extension apparatus, for it pulls the overlapping fractured ends apart by drawing the shoulder outwards, backwards, and upwards.

Two strips of strong adhesive plaster, spread on sail-cloth, 3 to 4 inches wide, are cut, one of which must be long enough to pass around the arm, and then around the chest, and the other long enough

Fig. 255.

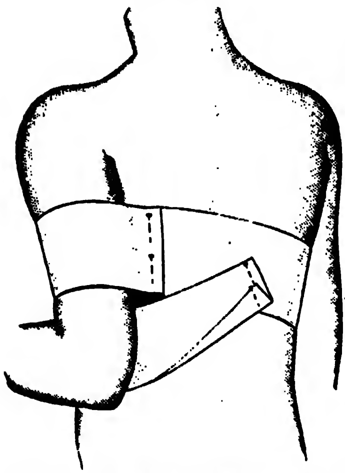


Elastic extension of the wrist.

to reach from the sound shoulder over the elbow of the injured side and then back again to the sound shoulder.

The first strip is passed around the arm below the axillary folds, and sewed together behind to form a loop large enough to leave a part of the back of the arm free, so that there shall be no strangulation. By this strip the arm is drawn backwards and downwards until the stretching of the pectoralis minor depresses the sternal (internal) fragment sufficiently. The arm is fixed in this position by passing the strip around the chest and securing the end to the main part behind (Fig. 256).

Fig. 256.



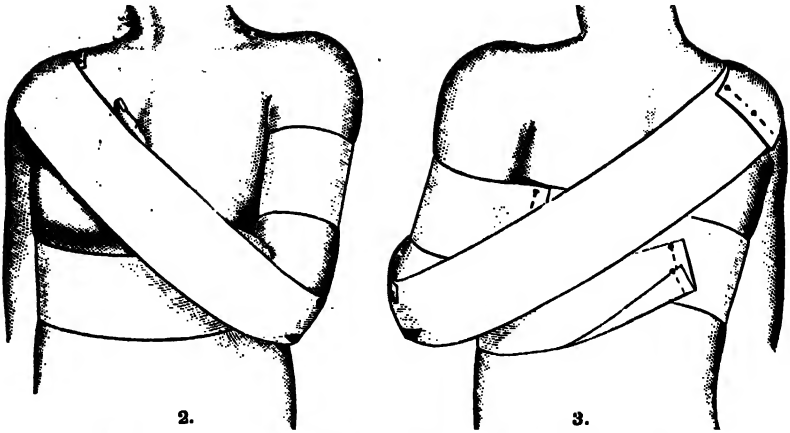
Sayre's adhesive plaster dressing for fracture of the clavicle. 1.

A small longitudinal slit is cut in the middle of the second strip to receive the point of the elbow. The forearm is bent at an acute angle and laid against the chest, and while an assistant presses the elbow forwards and inwards (thus completely reducing the deformity of the fracture) the arm is fixed in this position by the second strip, which supports the point of the elbow, both ends being passed over the back and front of the chest towards the sound shoulder, where they are crossed and fastened together with pins. (Figs. 257 and 258).

EMERGENCY DRESSINGS.

If the ordinary materials for dressings hitherto described (for dressing wounds, making splints for broken bones, and stopping hemorrhage) fail, it becomes the duty of the surgeon, and if a surgeon

Fig. 257. Fig. 258.



Sayre's adhesive plaster dressing for fracture of the clavicle.

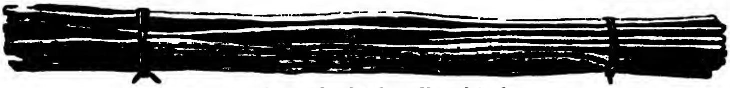
is also lacking, of the person rendering „first aid", to **improvise** these dressings from whatever materials are at hand.

EMERGENCY SPLINTS.

Splints are improvised out of a great variety of objects found in the fields, the woods, and on the field of battle, for example:

a. Of **twigs,** tied together in bundles (Fig. 259), or placed in a layer side by side and secured by cross-pieces of wood tied across

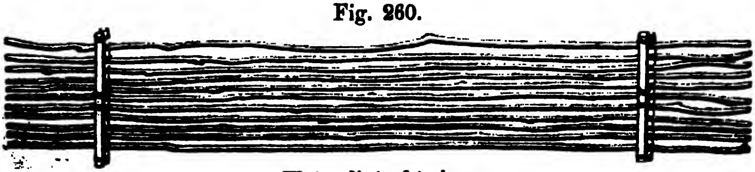
Fig. 259.



Splint formed of a bundle of twigs.

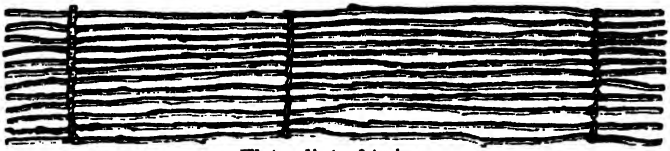
them (Fig. 260), or by strings twined through them like a chain, so that they can move upon each other (Fig. 261).

Fig. 260.



Flat splint of twigs.

Fig. 261.



Flat splint of twigs.

b. Of **straw** or **rushes**, for instance, by tying the best stalks of straw into bundles (Fig. 262), and wrapping two of these bundles in

Fig. 262.

Splint made of a bundle of straw.

the edges of a cloth, the middle of which has been placed under the injured limb, until they lie close to the sides of the limb, and can be firmly secured to it by cords (Fig. 263).

Fig. 263.

Splint of straw rolled in cloth.

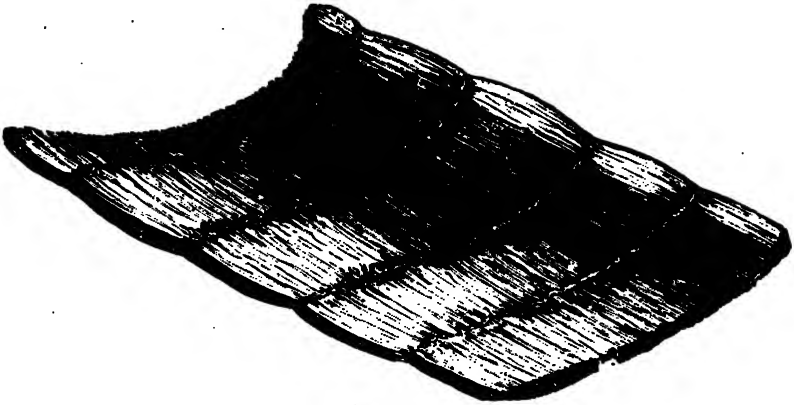
The stalks of straw, or rushes, can also be sewed together into **mats** (according to Beck) and the limb may be surrounded with these, or they may be rolled up and used as side splints (Fig. 264, and 265).

The French, for instance, in their sallies at the siege of Paris, employed the straw mattresses, made to cover hothouse windows, for making splints for injured limbs (Fig. 266).

c. A movable trellis of small wooden rods, used in many places for covering flower pots, is an excellent material for splints. They may be had in all sizes up to a length of 20 inches and more (Fig. 267).

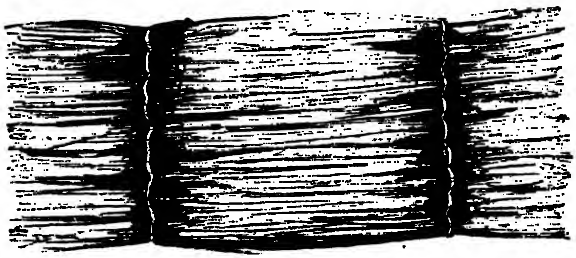
d. **Weapons** of every kind, such as are found on the field of battle — sidearms, faggot knives, bayonets with their sheaths (Figs.

Fig. 264.



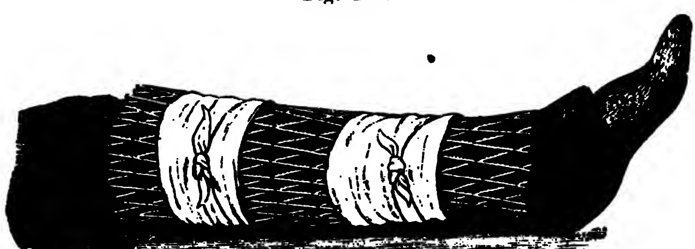
Straw mat.

Fig. 265.



Mat of rushes.

Fig. 267.



Splint made of flower-pot trellis.

268 to 270), muskets (Fig. 271), carbines, ramrods, pieces of lances, spokes of wheels, etc.

Fig. 266.

French sanitary corps before Paris, fitted out with straw-mats.

Fig. 268.

Splint made of two bayonets.

Fig. 269.

Bayonet splint.

Fig. 270.

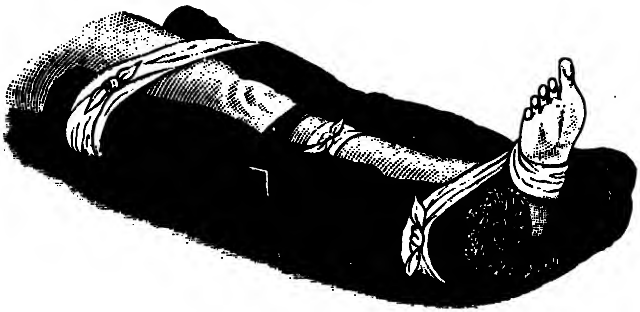
Bayonet sheath as splint.

Fig. 271.

Musket used as a splint.

The cut fragments of uniforms, also, should not be thrown away, but used whenever it is possible for dressings — for instance, parts of cloaks (Fig. 272), coats, trousers, bootlegs, shakos, knapsacks, etc.

Fig. 272.



Cloak rolled up for a splint.

The sanitary corps must be taught to make emergency dressings, and to use weapons for emergency splints, in time of peace.

When cloth is lacking, the skirt of the coat (Fig. 273), or the sleeve of the coat or shirt can be employed as slings.

In injuries and inflammation of the hand, elevation can be secured for the latter, according to Gamgee, by pinning the sleeve to the front of the coat by several safety pins (Fig. 275).

Fig. 273.

Skirt of coat.

Fig. 274.

Sleeve, Emergency slingr.

Fig. 275.

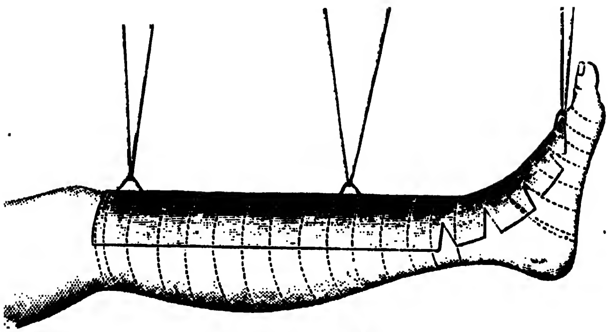
Pinned sleeve.

f. Splints can be cut from **sheet zinc** with strong scissors, and bent with the hands so as to fit the limbs closely. A splint for injuries in the region of the ankle may be taken as an example (Figs. 276 and 277).

Fig. 276.

Zinc splint.

Fig. 277.



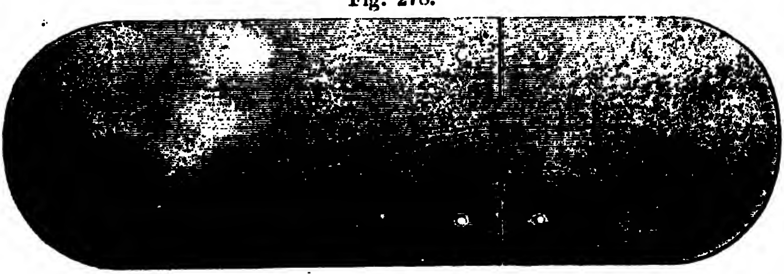
Zinc splint, applied.

In the substitute knapsack for the dressing station, introduced by the author, is a large box of sheet zinc, which gives shape to the whole, can be used as a vessel for water at the dressing station, and finally cut up into splints.

g. Pasteboard answers very well for splints, especially for injuries of the upper extremity.

Thus a splint can be very quickly made for the arm out of a piece of pasteboard 28 inches long, 10 to 12 inches wide (Fig. 278),

Fig. 278.

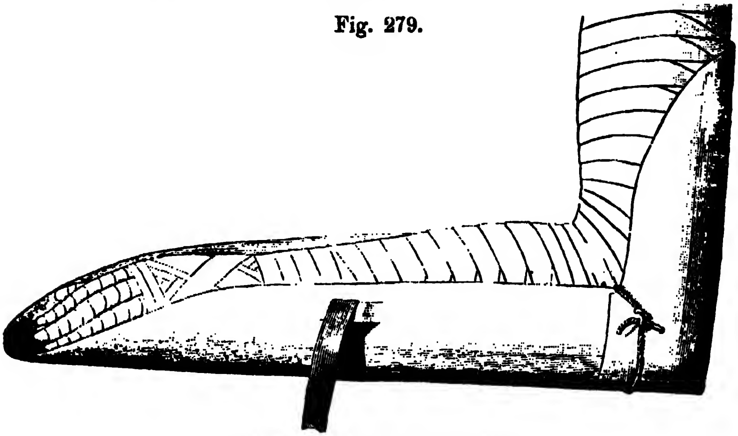


Pattern for pasteboard splint.

in which two cuts 3 to 4 inches deep have been made in the sides, between the first and second thirds.

This splint does good service as a provisional dressing for all injuries of the arm from the fingers up to the elbow, and above (Fig. 279). In fractures of the bones of the forearm it is best to place the forearm in a position of supination.

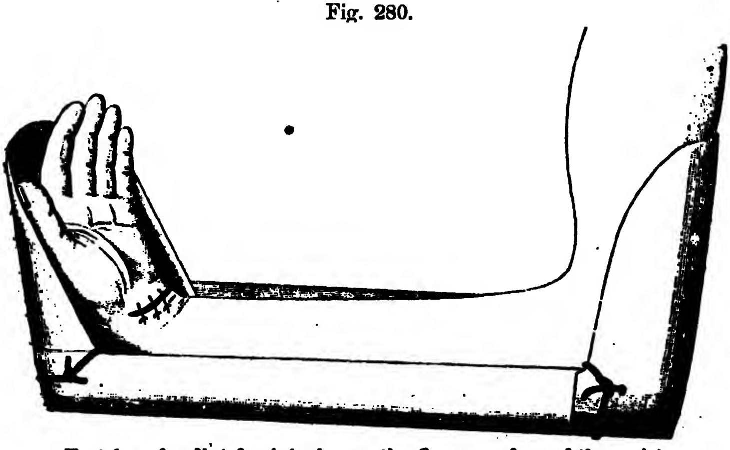
Fig. 279.



Pasteboard splint for the arm.

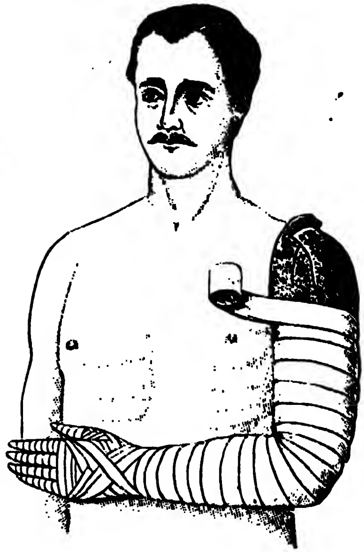
In wounds of the palmar surface of the hand, with injury of the tendons, a caplike addition can be made at the lower end of the splint and bent upwards in a similar manner, and the hand can thus be held in a flexed position (Fig. 280).

Fig. 280.



Pasteboard splint for injuries on the flexor surface of the wrist.

Fig. 281.

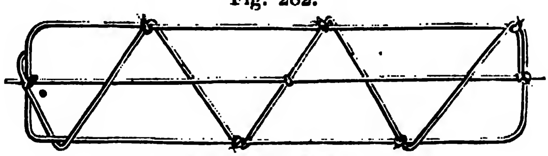


For fractures of the arm, especially at its upper part, four parallel cuts are made in one end of a broad pasteboard splint, the five divisions thus made are bent together over the shoulder, forming a shoulder cap, and the whole is secured by a spica bandage (Fig. 281).

h. The use of **telegraph wire** for splints of all kinds is of especial importance in war, because the destroyed telegraph lines are usually to be found everywhere, and because every hospital orderly, with a good pair of pincers and a file, is able to make these splints quickly, by following patterns, after a little practice.

Fig. 282 shows the simplest form of such splints, according to Porter, who first recommended the use of telegraph wire for this purpose. He also introduced a dressing scissors, with a file on one of its blades, with which the wire could be partly filed through so as to be easily broken.

Fig. 282.



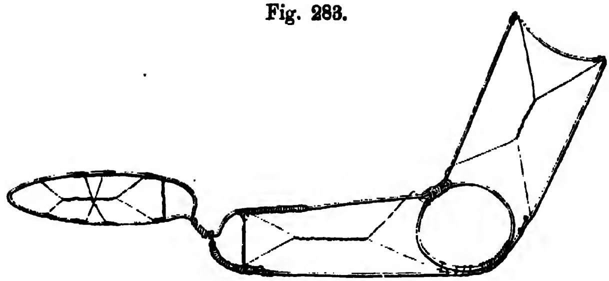
Splint of telegraph wire. (Porter.)

As telegraph-wire splints are just as useful as wooden and iron splints for most purposes — not only for emergency dressings, but also for the treatment of compound fractures, and of resections, it appears to me desirable that the field hospital should carry this wire into the field in considerable quantity, and also that the hospital corps should be practiced in making these splints in time of peace.

The following sketches show the somewhat complicated forms of telegraph wire splints which I now use almost exclusively for resections and compound fractures in my clinic (Figs. 283 and 284).

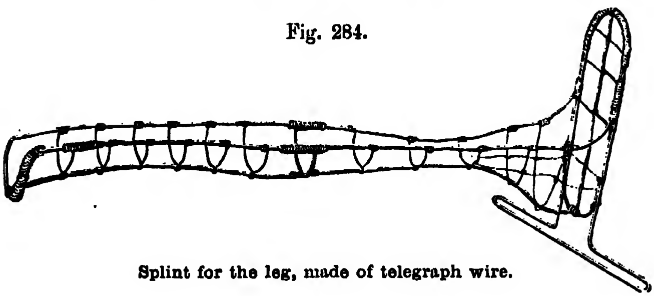
The skeleton of the splint is made of a single piece of thick wire, the length of which is calculated beforehand, bent, and the ends bound together with thinner wire which can be easily bent and twisted

Fig. 283.



Splint for the arm, made of telegraph wire.

Fig. 284.



Splint for the leg, made of telegraph wire.

by the fingers, and which is stretched and back and forth on the stouter wires so as to furnish a secure support to the injured limb [1]).

These splints are light and clean, and have the great advantage that the entire surface, and particularly the under surface, of the antiseptic dressing remains open to the eye; and as they are much cheaper to make than the wooden or iron splints, they are suitable for general use in the army hospitals as well as at the dressing stations.

The simple wire frames, over which strips of bandage are stretched by securing them with safety pins, are suitable for use with antiseptic irrigation, and with antiseptic compresses, the injured limbs resting comfortably upon them.

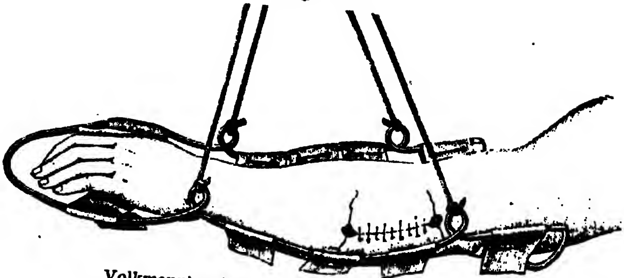
Wire suspension splints of this kind have been introduced by Volkmann for the upper extremity (Fig. 285), and by Bardeleben for the lower extremity (Fig. 286).

1. In war there is often a lack of tables and similar apparatus by which to apply the necessary dressings quickly and conveniently.

In such cases, the edge of a ditch, or an earthen wall can be used. A support which considerably lightens the work can also be

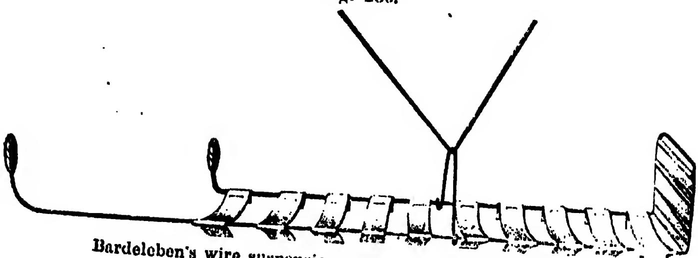
[1]) The wire for the splint for the leg must be about 15 feet long; that for the arm, about 8 feet.

Fig. 285.



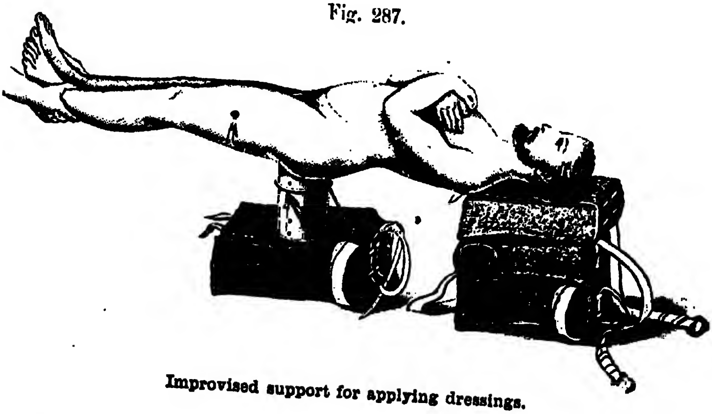
Volkmann's wire suspension splint for the arm.

Fig. 286.



Bardeleben's wire suspension splint for the lower extremity.

Fig. 287.



Improvised support for applying dressings.

quickly constructed out of knapsacks and camp kettles, which lie scattered about after a battle (Fig. 287).

THE SOLDIER'S DRESSING-PACKAGE.

According to the order of the army sanitary department, dated January 10th., 1878, every soldier must carry in war a package of materials for dressings consisting of: — a piece of old linen 30 centimeters square, a small triangular cloth of muslin (four such pieces are cut from a square meter) and 15 grams of lint.

Very different views prevail anong military surgeons as to the proper constituents of this package; and, indeed, on the main question, whether it is wise to have the soldier carry these materials for dressings with him into the field. Some consider it altogether unnecessary.

But I have heard from many experienced military surgeons that the surgeons in the field often had to rely, in dressing the wounded, solely upon the package of dressings which each soldier carried. This was the case, not only in campaigns in distant countries (in the war with the Boers, in the Ashantee war, in Egypt, and in the Caucasus), but even in our last war, when, especially in the cavalry, there were very often no other materials to be had than those which were found in the pockets of the soldiers. I therefore remain firm in my opinion, that humanity demands, that every soldier should carry with him in war a package of dressings with which his wounds can be dressed antiseptically, when other materials fail.

For many years I have interested myself in the question of what the dressing-package of the soldier should contain, and how it should be packed. In 1869 I published a little work under the title „Der erste Verband auf dem Schlachtfelde" („The First Dressing on the Field of Battle"), which contained, as an appendix, a triangular cloth printed with a copper engraving illustrating the use of Major's three-cornered cloth at the dressing station.

During the French war, the „Hülfsverein" (Sanitary Aid Society) of Kiel made large numbers of packages of dressings according to my plan, and distributed them to our soldiers. Each of these contained, besides the three-cornered cloth with a safety pin (Fig. 288), two wipers (b, and c), filled with carbolized cotton, and a gauze bandage (d), all wrapped in parchment paper (a).

As it afterwards proved that the carbolic acid quickly evaporated, I employed salicylated cotton instead; later, because the salicylic acid fell out of the cotton when the package was carried for some time, I substituted for it balls of jute with chloride of zinc; and, finally, wipers of sublimate sawdust.

Then, because of the objection made from military quarters, that it was not advisable to give the soldiers a picture representing „the horrors of the field of battle", to carry with them in war, I had another triangular cloth made of the cheapest cotton stuff, upon which were printed only six naked figures, showing the different methods of using the cloth in dressings. This cloth is now in general use for

Fig. 288.

First dressing on the field of battle. Kiel, 1869.

teaching the „first aid to the injured", not only in our „Samariter" schools, but also in the large „Ambulance Association" of England and America.

I have always endeavored to follow the improvements in antisepsis in composing these packages, so the latest form, with the title „Nothverband für das Schlachtfeld" („emergency dressing for the field of battle") (Fig. 289, page 139) contains, in addition to this cloth, two compresses of bichloride gauze (a, and b) (40 inches long, by 4 inches wide) each wrapped in varnished paper, and a bichloride cambric bandage (d) (2 yards long, by 4 inches wide) so that even large wounds can be covered with the antiseptic material.

The whole (a), strongly compressed, is wrapped in very durable rubber cloth, and forms a package $^3/_5$ of an inch thick, and 4 inches square, weighing exactly $3^1/_3$ ounces, and has the following directions printed on it:

„In simple gunshot wounds, a compress is to be laid upon each opening, after removing the varnished paper.

For larger wounds, the compresses are to be unfolded, and an attempt made to cover the entire wound with antiseptic gauze.

The gauze is to be secured upon the wound with the bandage.

The three-cornered cloth serves to cover this dressing, to support the injured limb, or to secure emergency splints, as is shown in the picture on the cloth."

I refrain from expressing any opinion upon the best place in the uniform in which to carry these packages. That is for the military staff to say. I will only remark that the contents can be easily made into a package twice as large, but half as thick, so that it could be sewed into one side of the breast of the coat. [1])

ANTISEPSIS IN WAR.

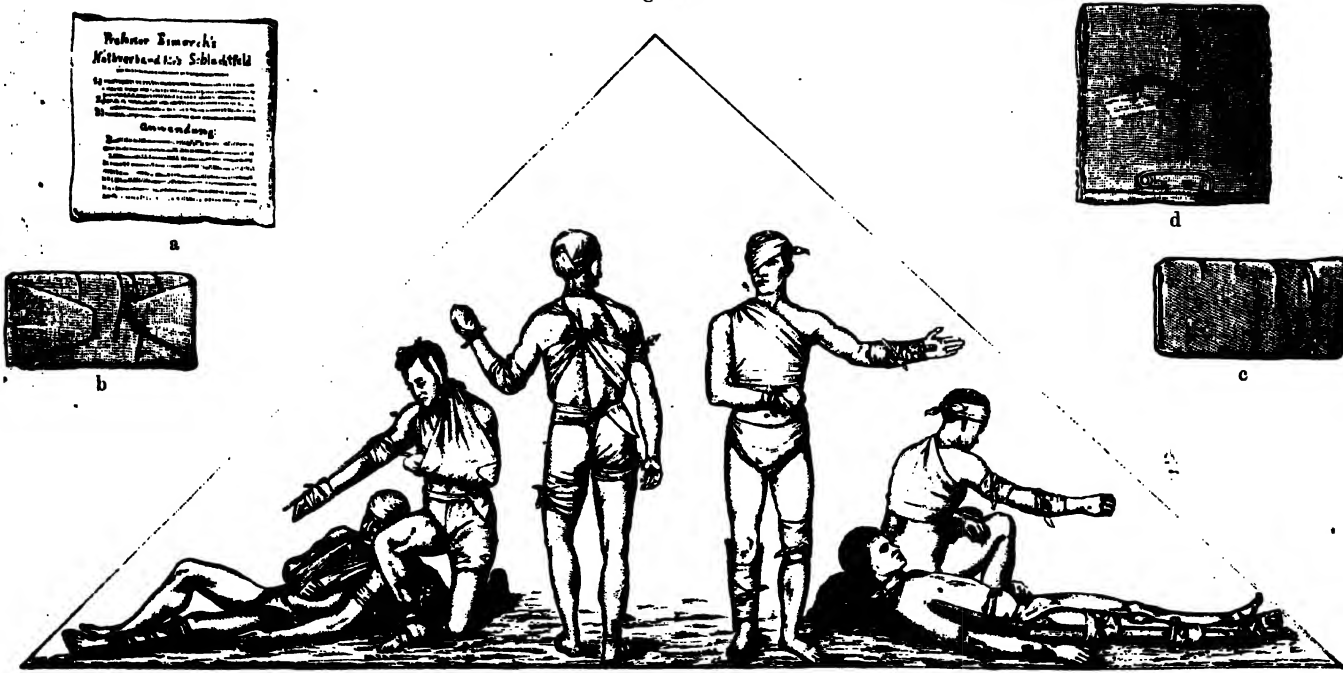
By way of conclusion, I will condense into a few short sentences my views upon the **application of antisepsis to military surgery,** with reference to what has been already said, as I presented my opinion to the International Medical Congress, at Copenhagen, in 1884, during which, in the section of military medicine, the following question was put: —

Is it possible at present to arrange a **reliable and simple antiseptic method of dressing wounds** so that the necessary **materials for dressings** shall have so **little bulk** that the method can be used in the field?

---

[1]) The instrument maker H. Beckmann, of Kiel, provides these dressing packages at 50 pfennigs apiece — about 12 cents.

Fig. 289.



The first dressing. Düsseldorf, 1873.

1. It is a pressing demand of humanity that the protection and advantages of the antiseptic treatment of wounds should be enjoyed by all the wounded, even in war.

2. To answer this demand, it is necessary that: —

a. All military surgeons should be perfectly familiar with the antiseptic treatment, and experienced in applying it.

b. The sanitary corps of lower rank (hospital orderlies, litter-bearers) should be taught the fundamental principles of antisepsis, and educated in rendering assistance in carrying out its measures.

c. Not only the field hospitals, and the sanitary corps, but also the medicine wagons of the regiments, the dressing knapsacks, and the pockets of the hospital orderlies must be sufficiently supplied with antiseptic dressing materials.

d. Every soldier should carry in war a package of materials for dressings, with which an antiseptic protective dressing can be provisionally applied in case of need.

3. All the materials for dressings should be **packed** as **closely** as possible, so as not to occupy too much space, and should be already **divided** for dressings of different sizes, so that they can be applied without loss of time.

If the requisite material has to be taken from larger packages at the time when it is needed, waste is almost unavoidable, and infection of the whole by dirty hands, dust, etc., is greatly to be feared.

4. As the **bichloride of mercury** has proved itself, up to the present, the most efficient of all disinfecting substances, it would be the best to employ for impregnating the materials for dressings.

5. As the material for the dressings, **surgical gauze** (unbleached gauze) best answers all the requirements; and it is to be used both in the form of compresses to cover the wounds, and in the form of bandages to secure the dressings.

6. Therefore, gauze impregnated with 1 to 1000 bichloride solution (**bichloride gauze**) is proposed as the **single dressing material.** The volume can be considerably reduced by **compression.**

7. From this bichloride gauze, **pieces of one size** can be cut which can be employed as **compresses** for all sorts of wounds.

Should, for example, a size of 20 inches square be chosen, one such piece, folded so as to make four thicknesses, could be used as the first covering for a simple gunshot wound, while ten such pieces laid upon each other without folding would serve as the dressing for a large wound — after amputations, resections, etc., for instance.

8. From the same material, **bandages of a fixed width and length** could be made, which could be used for all sorts of wounds.

Should for example, a size 4 inches wide and 5 yards long be chosen as a **standard bandage**, it could be employed for securing

gauze compresses upon wounds of every size. If a narrower bandage were needed, the rolled up bandage could easily be divided into two parts with a sharp knife.

9. In case of need, a compress of any desired thickness can be made of this bandage by folding it back and forth upon itself.

10. A **carbolic acid solution** for disinfecting the hands and instruments cannot very well be dispensed with. Materials should therefore be at hand, both in the field hospitals, and in the chief dressing station, from which large quantities of this solution can be quickly prepared.

For the field hospital, large quantities of crystallized carbolic acid must be carried, together with instruments for measuring it.

For the chief dressing station, and the sanitary corps, it would be advisable to carry carbolic acid in solution, in small glass vessels of such a size that the contents of one of them poured into a vessel of known capacity (irrigator, basin, jar) would make a solution of a certain strength, for the inferior members of the sanitary corps are far too apt to make mistakes in the preparation of solutions.

The **carbolic spray** can be dispensed with in practice in the field; and also protective silk and mackintosh. In case of need, the latter can be replaced by varnished tissue paper.

11. In order to be able to prepare **fresh antiseptic materials** quickly, if the supply of materials for dressings which has been carried should fail, sufficient bichloride (dissolved in $2^1/_2$ parts glycerine) should also be taken, and the sanitary corps should be instructed how to transform a great variety of stuffs (gauze, cotton, jute, peat, moss, lint, sawdust, wood-wool) into materials for antiseptic dressings.

12. **Powdered iodoform**, in sprinkling boxes, can scarcely be dispensed with for some kinds of wounds, but in general its antiseptic powers do not compare with those of the bichloride.

13. **Bichloride catgut** of various thicknesses, and **drainage tubes** of various diameters, must be at hand in sufficient quantity.

14. **Sponges** should not be used at all at the dressing station, because it is impossible to protect them from infection. In their place, **wipers** are to be employed, made of antiseptic material (balls of bichloride wood-fibre tied up in gauze) moistened with bichloride solution before use. They should be destroyed after having been used once.

15. The surgical instruments should have as few grooves and depressions about them as possible, because the agents of decomposition are liable to become so fixed in them that they can not be removed by ordinary means of cleansing.

16. By the use of these materials, not only in the **field hospitals**, but also at the **chief dressing stations**, all wounds can be dressed strictly antiseptically, and operations may even be performed in an antiseptic manner.

17. When strict antisepsis cannot be carried out, as, for instance, in the **regimental dressing stations**, the first principle of every wound treatment should govern what is undertaken — **„at least do no harm“.**

18. Therefore **avoid any examination of wounds** with fingers or instruments which are **not surgically clean** (aseptic), for the agents of decomposition invariably adhere to fingers and instruments which have not been cleansed, and they are wiped off, and left in the wound during the examination, and cause inflammation, suppuration, and wound decomposition.

The only exception to be made to this rule is when life is threatened, by hemorrhage, for then **quick** treatment is most important.

19. Extraction of bullets without antiseptic precautions is by no means to be allowed. A **projectile** in the body does but little harm in itself. Bullets often become encapsuled in the body without giving rise to any subsequent trouble.

Experience teaches that even very severe internal injuries (of bones, joints, tendons, nerves, lungs, heart, brain, etc.) which have been produced by bullets in their course, may heal without fever and without complications, if no agents of decomposition have entered the wound.

20. Wherever strict antisepsis cannot be carried out (for instance, at the regimental dressing station) the surgeon should abstain from any operative measures. His only duties at that point are:

1. To apply **temporary** dressings — that is, to cover fresh wounds with abundant antiseptic material, to protect them from the entrance of the agents of decomposition.
2. To immobilize the injured parts (fixation by cloth, splints, etc.).
3. To send the wounded as quickly as possible where the wounds can be treated with strict antisepsis.

21. If on the arrival of a wounded man at the **field hospital** with a temporary dressing, no symptoms appear which render an internal examination of the wound necessary (fever, pain, hemorrhage, penetration of the dressing by the discharge of the wound), the wound should **be left untouched**, and the first occlusive dressing should **not even be removed**, for many gunshot wounds may heal under the scab, without suppuration, without fever, and without other complications.

22. But if symptoms appear which render an examination of the wound necessary, the dressing must be at once removed and an energetic **antiseptic treatment** of the wound undertaken. In addition to the major operations which may appear necessary, amputations, resections, etc., this requires in the first place, free opening, drainage, and thorough disinfection with efficient antiseptic substances (such as chloride of zinc, bichloride of mercury, iodoform, etc.); and in the second place, the application of an antiseptic dressing.

23. The **litter bearers** should place the wounded on the litters with **great care**, and carry them to the dressing station as quickly as possible, if the latter is near by.

24. Only in case no surgical aid is near, or no more material for dressings is to be had, should the **dressing package** which the soldiers carry be used, by the wounded themselves, or by the litter bearers. This is most likely to occur in the cavalry division.

In addition to the antiseptic material for dressings (two bichloride gauze compresses, and a bichloride gauze bandage) these packages must also contain a three-cornered cloth, with which the protective dressing can be covered, fixation of the injured limb made, and an improvised splint secured.

PART II.

OPERATIVE SURGERY.

CHLOROFORM ANAESTHESIA.

1. In every major operation, and for every prolonged painful examination, the patient should be rendered anaesthetic by **inhalation of chloroform** (Simpson, 1847).

2. Under some circumstances, however, this wonderful drug may be dangerous to life, therefore certain **prudential rules** are to be observed in its administration.

3. The patient to be chloroformed should **fast**, taking no nourishment for three or four hours beforehand. During the operation he **should lie upon his back**, or **on one side, not on his abdomen**, because the last position interferes with the respiration. He should **not sit up**, because fainting is more likely to occur in a sitting posture; most of the fatal cases have occurred during small operations when the patient was allowed to sit up.

4. Shortly before beginning the administration of the chloroform, a subcutaneous **injection of morphine** (gr. $^1/_6$ to $^1/_3$) is given, which quiets the patient and hastens the anaesthesia. It also considerably lessens the pain in the wound after recovery from the anaesthetic — combined **morphine-chloroform anaesthesia.**

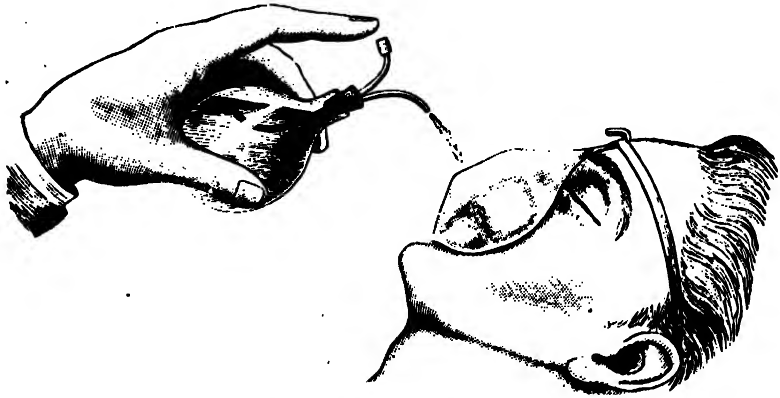
5. All **constricting** clothing is to be **removed,** so that the neck and chest are free and the abdomen is easily accessible.

6. During the administration of the chloroform, **pulse and respiration** must be kept **under observation.** If enough assistants are present, the respiration can be watched by the person administering the chloroform, and the pulse watched by the two assistants who hold the arms.

7. The **chloroform vapor** must be abundantly **diluted with atmospheric air** when inhaled. It is dangerous to press a thick cloth or sponge upon which chloroform has been poured, close to the mouth

and nose. It is far better to employ a wire frame (wire-mask) covered with a piece of loosely woven woolen cloth upon which the chloroform is poured one drop at a time — as, for example, in the Skinner **chloroform inhaler,** simplified by the author, with its accompanying **drop-bottle** (Fig. 290). This apparatus can be easily carried in the

Fig. 290.



Esmarch's chloroform inhaler.

pocket, packed in a leather case with a tongue forceps. Sufficient atmospheric air will be drawn through the cloth with every respiration. Care must be taken not to pour the chloroform on so freely as to make it drop from the inner side of the cloth; and also not to allow it to flow over the sides upon the skin, and especially into the eyes, as it may excite violent inflammation. The mask should not be closely applied at once, but should be gradually lowered over the mouth.

8. Chloroform generally causes an excitement like that of alcoholic intoxication at first — the **stage of excitement,** to which succeeds, after a longer or shorter time, the **stage of toleration.** Movement gradually ceases, and sensibility is extinguished, together with consciousness, the cornea and the mucous membrane of the nose becoming insensible last. By touching these parts it can be ascertained when the anaesthesia is deep and complete, for then no reflex movements will be caused by the irritation.

9. Chloroform, however, **paralyzes** the vaso-motor centers in the medulla oblongata, and the motor ganglia contained in the heart, and so weakens both respiration and heart action. The respiration accordingly becomes more rapid, and shallower; and the pulse smaller, and feebler. The blood consequently grows darker and more venous, because it contains more carbonic acid. The arterial pressure is lowered, the temperature of the body falls, and the chemical changes are retarded.

10. If there is anything in addition which interferes with respiration and with heart action, the condition becomes dangerous, and demands quick and skilful **assistance.**

11. A **sudden cessation** of the movements of the **heart** and **respiration** may appear even in the first stage, in consequence of the inhalation of concentrated chloroform vapor. This is probably to be considered as **an inhibitory reflex** from the pneumogastric nerve, caused by irritation of the terminations of the trigeminus in the mucous membrane of the mouth and nose.

After several stertorous respirations, with violent convulsive muscular movements, the respiration entirely ceases; the abdominal wall is retracted and as hard as a board; the pulse becomes slow, then imperceptible; the face turns dark-red; the jaws are locked; the tongue is drawn convulsively backwards, and closes the glottis by its pressure **(convulsive asphyxia).**

12. In the **stage of deepest toleration** the entrance of air into the trachea is not infrequently impeded by the tongue, which falls backwards against the posterior wall of the pharynx, on account of the relaxation of the muscles, and mechanically obstructs the glottis. In old people, moreover, the closed relaxed lips may act as valves in inspiration, falling against the toothless jaws, and the relaxed nostrils may be drawn against the septum and thus prevent the entrance of air.

In either case the respiration becomes difficult and snoring, the face turns blue, the blood very dark, and the pulse irregular and weak **(paralytic asphyxia).**

This accident is the more dangerous as the symptoms do not begin with such violence, but the blood, already very venous, becomes in a short time quite overloaded with carbonic acid.

13. The most dangerous accident is sudden **paralysis of the heart** (syncope), and this may occur in any stage of chloroform anaesthesia, and quickly cause death. In this case the pulse quickly becomes imperceptible, and while the respiration may continue for some time, although superficially and irregularly, the face becomes as white as death, the pupils dilated and immovable, and the jaw falls. The hemorrhage from the operation wound ceases. Collapse of this kind may occur at the very beginning of the anaesthesia under the influence of fear, in weakly individuals with a tendency to fainting, but it takes place by preference in **acute anaemia** (after severe injuries with great loss of blood) and in **chronic anaemia**, and especially in muscular degeneration of the heart (fatty heart, atheroma of the arteries, alcoholic dyscrasia) which disposes to early exhaustion of its powers.

In such persons, therefore, particular care is necessary, and the heart should always be examined before chloroform is administered. Unfortunately in many cases, fatty degeneration of the heart cannot be recognized with certainty.

14. As soon as symptoms of this kind appear during chloroform anaesthesia, the **inhaler** must be **immediately removed** and an attempt made to **restore the halting respiration** and **heart action**.

15. **In asphyxia,** open the mouth at once, and press the lower jaw forwards with both hands by placing the forefingers behind the ascending ramus, so that the lower teeth project in front of the upper (partial dislocation) (Fig. 291). By this movement the hyoid bone

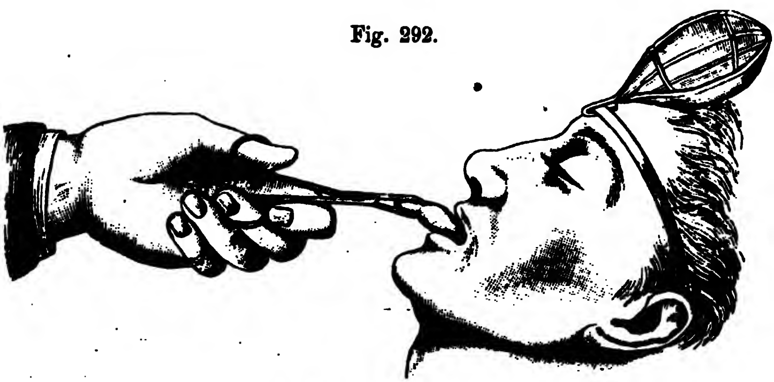
Fig. 291.

Raising the jaw in the paralytic asphyxia of chloroform anaesthesia.

the root of the tongue, and the epiglottis are drawn forwards, and the entrance to the larynx is thus freed from obstruction.

If this can not be accomplished because of convulsive contraction of the muscles, separate the teeth with a dilator, seize the end of the tongue with the fingers, or with a tongue forceps (Fig. 292), and draw it out of the mouth as far as possible.

Fig. 292.



Drawing out the tongue in convulsive asphyxia.

16. If in spite of this, the respiration remains difficult and rattling, the cause may be the presence of mucus or blood in the chink of the glottis. Remove this by a sponge, carried down to the larynx on a dressing forceps.

17. If **respiration ceases entirely, artificial respiration** must be instituted at once — and preferably by Sylvester's Method. While the tongue remains drawn forward, or is secured to the chin by a rubber ring, stand behind the patient's head as he lies on his back, seize both arms below the elbows and draw them above his head. Hold them stretched upwards in this way for two seconds, then bring them down again and press the elbows gently but firmly against the sides of the chest, the left nearer the middle line, opposite the region of the heart. Repeat this up-and-down movement of the arms about fifteen times in the minute, quietly and correctly, until spontaneous respiratory movements begin again (Figs. 293, and 294).

18. By **stimulating the skin** in certain ways, reflex respiratory movements can be started or assisted. The most efficient means for applying this stimulation are: — striking the chest and abdomen with a wet towel, sprinkling the epigastrium with cold water, rubbing ice or snow on the nape of the neck, injecting cold water into the nose, introducing a piece of ice into the rectum, and irritating the nasal mucous membrane with the electric current.

19. If **syncope** occurs, artificial respiration is to be instituted immediately. It is then important to place the **head low** and to **elevate the body,** and this is most easily accomplished by raising the end of the table upon which the feet of the patient rest (Figs. 293, and 294). (Nélaton's method by inversion.)

In this way the flow of the stagnant blood away from the right side of the heart and towards the brain is accelerated. For the same reason, the left elbow is to be **firmly pressed against the heart** every time the chest is compressed.

If the movements of respiration and of the heart do not at once reappear, the effort to restore them should not be discontinued too soon. Cases are known in which, even after three or four hours of continued artificial respiration, the suspended animation was successfully recalled.

20. In such cases an attempt may also be made to set the inspiratory muscles in motion again by **stimulation with electricity,** [1]) by firmly pressing both electrodes of an induction apparatus in the depression above the clavicle, behind the external edge of both sternomastoid muscles, so that the two phrenic nerves and the other nerves of inspiration contained in the brachial plexus shall be affected by the current.

---

[1]) Electro-puncture of the heart, recommended by Steiner, is certainly not to be advised, and it could scarcely effect more than direct compression of the heart in artificial respiration. But in desperate cases it would be well to make a trial of the subcutaneous injection of strychnine (grain $\frac{1}{30}$ to $\frac{1}{10}$) (Liebreich)

Fig. 293.

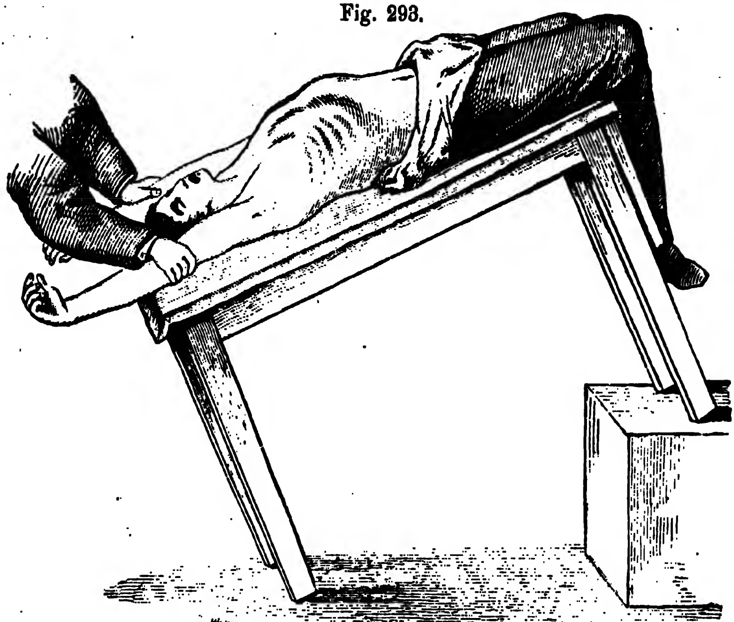


Fig. 294.

Artificial respiration by Silvester's method.

21. Should **vomiting** take place during anaesthesia, turn the head away from the injured side at once, so that the vomited materials shall not find their way into the air-passages, or the wound.

22. When **great exhaustion** and heart — weakness are present, give the patient a glass of strong wine shortly before the anaesthesia is begun.

23. If there is **great excitement** in the first stage, too much force must not be employed to restrain the patient. It is preferable to inject some morphine subcutaneously.

TREATMENT OF SEPTIC WOUNDS.

SECONDARY ANTISEPSIS.

Every wound which has not been made by aseptic instruments and with antiseptic precautions, is to be considered septic — suspected of infection, and to be treated accordingly — that is, disinfected.

Simple gunshot wounds which pass entirely through any part of the body can generally be considered aseptic, because all the agents of infection which may have been adherent to the ball are destroyed or made harmless by the heat acquired by the ball in its flight.

Experience also teaches that many such gunshot wounds heal under the scab without inflammation or suppuration, when simply occluded antiseptically, if septic material has not been introduced into the track of the wound by examination with fingers or instruments which are not clean.

For the same reason, **bullets** which have remained in the body heal in without exciting inflammation or suppuration, even if they have injured bones, joints, or other important organs in their course.

But if the ball has carried with it into the wound, pieces of clothing, or anything else to which the agents of infection are attached, these will in most cases cause inflammation and suppuration sooner or later.

Since this can not be ascertained from the outward appearance of the wound, it is advisable to consider every gunshot wound aseptic in the first place unless it is complicated with severe hemorrhage, considerable extravasation of blood, great comminution of the bones, and injury to the joints — and accordingly, to **refrain from any examination of the wound,** and merely to apply an **antiseptic occlusive dressing.**

Simple antiseptic occlusion consists in carefully cleansing and disinfecting the neighborhood of the wound, then laying upon the wound an antiseptic dressing (bichloride gauze, peat-bag, iodoform powder, etc.) and securing as good fixation to the injured part as possible (handkerchief dressings, splints, plaster of Paris dressings, position apparatus).

If a plaster of Paris dressing is applied for an uncomplicated gunshot fracture, an antiseptic wiper must be laid upon the wound, in order that an opening may be cut at the right place.

Wounds with such extensive loss of skin that they can not be closed by suture or by plastic operation (injuries from fragments of a bomb, large shot, machinery) should be covered with antiseptic dressing material (bichloride gauze, iodoform gauze, bichloride peat-bags) under which aseptic suppuration and granulation can take place.

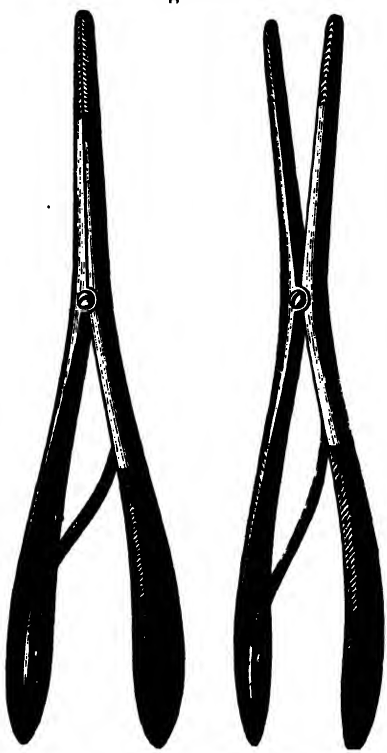
Every fresh wound which has been evidently **infected,** and every wound which was at first considered aseptic, but in which **symptoms of sepsis** (abundant discharge, pain, swelling of the neighborhood of the wound, inflammation, suppuration, wound-fever) have appeared, must be immediately subjected to a **thorough disinfection (secondary antisepsis),** and this must be energetic in proportion as the septic symptoms are threatening.

The same principles apply here as in primary antiseptic treatment of wounds, and since the necessary proceedings are for the most part very painful, it is advisable to put the patient on the operating-table and to administer chloroform — so as not to be prevented by his complaints and restlessness from carrying out the disinfection with proper energy.

As in all operations, begin with a careful cleansing and disinfection of the entire neighborhood of the wound; cut off the arterial blood-supply, if the wound is situated upon an extremity, with the elastic band, after perpendicular elevation of the limb; enlarge the wound by freely incising the skin and by tearing open the deeper soft parts with the fingers, the dressing-forceps, or the dilating forceps (Fig. 295); and hold the wound open with retractors (Figs. 296 to 299) so that its interior is completely exposed to the eye.

All blood-clots (and granulations) are next scraped out with the fingers, with wipers and sponges, and with the sharp spoon

Fig. 295.

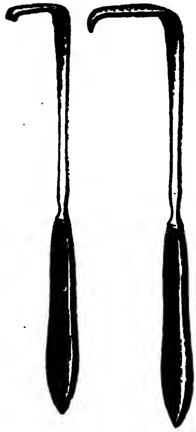


Roser's dilating forceps.

Fig. 296.

Volkmann's retractor.

Fig. 297. Fig. 298.



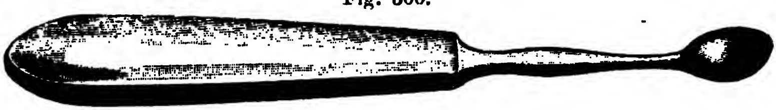
von Langenbeck's blunt retractors.

Fig. 299.

Improvised retractor.

(Fig. 300); all shreds of tissue and layers of cellular tissue infiltrated with blood or pus, and all portions of muscle which have been contused, are

Fig. 300.



Sharp spoon.

removed by forceps, scissors or knife; every foreign body (bullets, fragments of clothing, loose splinters of bone, earth, dirt) are removed; the finger is forced into every pocket and sinus of the wound, and incisions are made through the fascia and skin at the end of the latter (button-holes) so that drainage tubes can be inserted into them.

Then follows a thorough washing out and irrigation of the cavity of the wound with antiseptic solutions, the strength of which must be proportioned to the degree of sepsis already existing.

In the lighter cases the weak (3 %) carbolic or (1 to 5000) bichloride solutions; in the severer cases stronger solutions — 5 % carbolic, 1 to 1000 bichloride, or 8 % chloride of zinc solution, are to be employed.

Then drainage tubes are to be inserted everywhere, particularly in the tracks of the bullets, so as to secure the escape of discharge

from every part of the wound — after which the incisions in the skin can be for the most part sutured, but not too closely.

Next follows an antiseptic compressive dressing, preferably of crumpled gauze, which is left until it is desired to remove the drainage tubes, and this should be done as soon as possible — in five or six days.

In this way primary union is often successfully achieved, even under such circumstances as these.

But if sepsis is already far advanced, if foul discharge, coating or gangrene of the surfaces of the wounds is already present, or if the contused soft parts are in a state of mortification, primary union must be relinquished, the wound sufficiently enlarged and left open, and covered with antiseptic materials (bichloride-gauze, iodoform gauze), or stuffed with them (tamponnade).

In large, open, septic wounds (contusion and laceration by large shot, or machinery, etc.) **antiseptic compresses** (gauze compresses wet in solutions of acetate of alumina, bichloride, or carbolic acid) are to be employed, and the compresses must be frequently renewed (every hour), and the wound irrigated with the same solutions every time the dressing is changed. Or **antiseptic baths** are used — that is, the injured part is allowed to lie day and night, or at least for many hours every day, in a bath of antiseptic solution — in a 2 to 3 % solution of sulphide of sodium for example.

But in the **worst** cases of **acute septic suppurative** inflammation (which sometimes appears in the first few days in cases with severe comminution, and with large diffuse extravasation of blood), in which quickly spreading gangrenous infiltration of the cellular tissue can be recognized by the hard, dark-red, painful, and oedematous swelling of the skin, extending rapidly over the entire limb, and accompanied by high fever, and by extreme loss of strength, **permanent antiseptic irrigation** sometimes renders excellent service. The object of this treatment is to cause fresh quantities of an antiseptic solution to constantly penetrate the wound, and by it to wash out the foul discharge.

To accomplish this, in addition to the measures already described, numerous small incisions ($^3/_4$ to $1\,^1/_2$ inches long) must be made through the skin and fascia (multiple scarification), in order to open the wound more thoroughly, especially wherever the skin had been raised from the parts beneath, to obtain free escape for the discharge, and to allow the antiseptic solution to penetrate everywhere into the deeper parts.

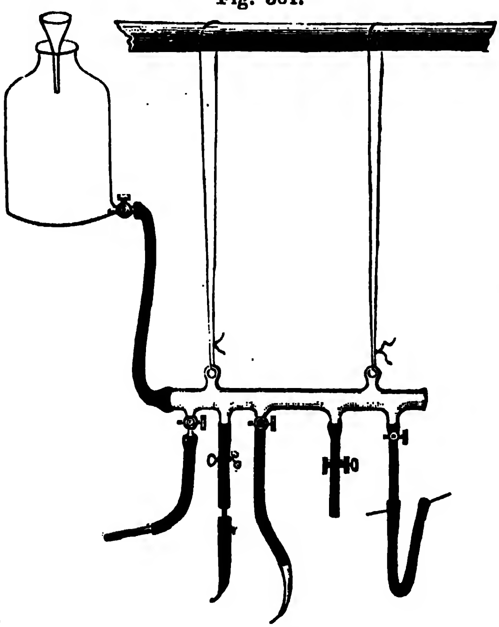
If the hemorrhage from the inflamed tissues is very severe, as it usually is, it will be best to control it at first by applying a firm bandage of gauze wet with antiseptic solution, which is to be left for some hours.

Then rubber drainage tubes are to be inserted into the bottom of the wound through all the openings, and in some of them are to be introduced the nozzles of irrigators which hang over the bed and contain harmless antiseptic solutions — for instance, solutions of acetate of

alumina (1 to 0,5 %), of permanganate of potash (3 %); or better, of hydrogen peroxide (3 %), of boric acid (4 %), or thymol (0,1 %) (Starke), for the two solutions first mentioned form sticky precipitates which obstruct the tubes and make a frequent washing out necessary. The poisonous antiseptics, carbolic acid, bichloride of mercury, etc., can not be used for this purpose without danger.

A stream of these solutions, the force of which is regulated by stopcocks, is allowed to penetrate into the wound. The solution escaping from the other drainage tubes, runs over a waterproof cloth laid under the limbs (Fig. 58), or a board (Fig. 57), and is received in a jar standing below. Bardeleben's (Fig. 286), or Volkmann's (Fig. 285) suspension wire apparatus answers very well to support the limb for this purpose. Starke's **apparatus for permanent irrigation,** which is represented in Fig. 301, is very useful. It consists of a metal tube

Fig. 301.



Starke's apparatus for permanent irrigation.

Fig. 302.

Volkmann's dropping nozzle.

20 inches long, and 2 inches in diameter, which has spouts for five rubber tubes; the latter are provided with glass nozzles which are inserted into the drainage tubes. The force of the stream can be regulated by stopcocks attached to each tube, and the tubes can be given any curve by means of wires which are placed in them.[1])

[1]) Centralblatt für Chirurgie, 1881, No. 18.

It is necessary to watch the working of the irrigating apparatus constantly. The antiseptic solution should not run through in a continual stream, but only in quick drops. To secure this, it is sometimes useful to put the glass **dropping nozzle** of Volkmann (Fig. 302) in the end of the irrigator tube.

When success in subduing the sepsis has been attained in some way or other, when laudable, not foul-smelling pus is discharged, and **healthy granulations** have formed, the stronger antiseptics can be given up, the wounds covered with mild antiseptic salves (ointments of boric acid, aluminium, or zinc) and the exuberant development of granulations held in check by touching them with the nitrate of silver stick, or by sprinkling them with astringent powders (sulphate of zinc, sugar, etc.).

To hasten the cicatrization of large granulating surfaces, the transplantation of skin by the method of Reverdin is employed with the best effects — small pieces being cut with scissors curved on the flat from the healthy skin of another part of the patient. The skin of limbs which have just been amputated can be used for this purpose. The pieces of skin should consist only of the epidermis and corium, and show no cellular or adipose tissue on the under surface. The granulating surfaces must have been made aseptic previously, by antiseptic compresses and irrigation. The pieces of skin, also aseptic, are laid on the granulations at suitable intervals, with their natural under surfaces downwards, gently pressed upon, and covered with pieces of gauze, or oil silk, and must lie undisturbed under an antiseptic dressing for at least five days.

If they adhere and live, the formation of epidermis spreads rapidly from their edges in all directions.

TREATMENT OF COMPLICATED INJURIES OF THE BONES AND JOINTS.

In fresh penetration fractures and **ordinary gunshot fractures**, even of the articular ends, if there is no considerable extravasation of blood, and no emphysema in the neighborhood of the wound, simple antiseptic occlusion (page 150) may be attempted, but the broken bones must be carefully immobilized by splints or stiff dressings, especially when the patient has to be moved any distance.

In severe compound fractures with considerable contusion and laceration of the soft parts, in gunshot fractures with great comminution, particularly of the articular ends, and also in ordinary gunshot fractures,

as soon as great pain, considerable infiltration of the neighboring parts, abundant discharge, high fever, and sepsis make their appearance, a **thorough disinfection** must be undertaken at once, as has been described above (page 151).

In carrying out this disinfection, the **fractured ends** of the bone must be **projected through** the enlarged wound by bending the limb, and carefully washed and disinfected.

If the wound in communication with the fracture is not favorably situated for this manoeuvre, it is better to expose the fractured ends by a large incision at some other spot, where they lie more superficially, and merely to place a drainage tube in the track of the bullet.

Any very **sharp corners** and **points** on the fractured ends are smoothed off with the bone-cutting forceps.

Only those **splinters of bone** are to be removed which are entirely detached, or remain in connection with the soft parts only by narrow strips of periosteum.

The **larger fragments of bone** which remain connected to the muscles and periosteum are not to be removed, but an attempt must be made to restore them to their proper positions.

If muscles have been caught between the fragments, or if the latter have imbedded themselves in the muscles, they must be disengaged and restored to their proper places.

To prevent the discharge of the wound from collecting about the fragments, the drainage tubes must be introduced as far as the point of fracture — but not between the broken ends.

Finally the entire wound is to be irrigated again with bichloride solution, until it returns clear from all the drainage tubes and apertures; then all the superfluous solution is to be squeezed out by pressure from every direction, and lastly a firm compressive dressing is to be applied.

If the operation has been performed by the bloodless method, and if all the vessels injured during the operation have been securely ligatured, the elastic band need not be removed until just before the completion of the dressing.

If fissures (cracks) extend from the point of fracture into a neighboring joint, and this can usually be recognized by the joint being filled with blood (hemarthrosis); or if the **articular ends** are themselves **comminuted**, the joint must be freely opened, so that the entire synovial sac can be exposed with the aid of sharp hooks, and all its pockets can be examined.

Then every blood-clot is washed out, every foreign body removed, and loose or crushed fragments of bone are also taken away. Large fragments of bone which are still in good connection with the soft parts, are restored to their position after thorough disinfection, and perhaps fastened there with nails, and the cavity of the articulation is carefully drained.

Those parts of the articular ends which are covered with cartilage may be left in place without disadvantage (partial resection).

If suppuration has already begun, all granulations are scraped away with the sharp spoon, after careful removal of the pus by irrigation. The contused parts of the capsule of the joint, and the parts which are infiltrated with pus, are extirpated with the scissors and knife; every suppurating pocket is opened, and, together with the cavity of the joint, furnished with free drainage by absorbable drainage tubes; and a large antiseptic dressing, which also secures fixation, is applied. This dressing may remain for many weeks, if high fever or some other symptom of sepsis, or the penetration of the dressing by the discharge, do not make it necessary to renew it sooner.

If rubber drainage tubes are inserted, they must be removed soon (in five or six days) otherwise they will delay the healing process.

If the comminution of the articular ends is considerable, and the decomposition of the soft parts is very threatening, **complete resection,** and perhaps **amputation** of the limb, must be taken into consideration.

INDICATIONS FOR AMPUTATION.

The **removal** of a limb is generally only indicated when, by this means, the prospect of **preserving** the **life** of the patient is rendered really better than by conservative treatment.

The decision of the question, whether primary amputation should be undertaken, depends more upon the state of the soft parts than upon that of the bones. Even extensive comminution of the bones no longer indicates that amputation is necessary if the soft parts are in good condition.

But in some cases only an **early removal** of the limb above the boundaries of the dangerous process can save life — as, for instance, if a limb has been torn off by a heavy shot, or the soft parts have been lacerated and contused for a wide extent; if a smaller ball has comminuted the bone, and at the same time torn through large vessels and nerve trunks; if gangrene has already appeared and threatens to spread from the point of injury; or if acute septic infiltration of the cellular tissue begins to extend uncontrollably towards the heart.

But if this indication for amputation is undoubtedly present, the operation should be undertaken **primarily,** that is, as soon as possible, and before the appearance of any inflammatory reaction.

FIXATION DRESSINGS IN COMPOUND FRACTURES AND INJURIES OF JOINTS.

It is of course understood that the limb is well immobilized, and held in the position desired by extension and contra-extension exercised by reliable assistants during the application of the dressing.

As antisepsis is of more importance than fixation in all severe injuries, at first, that part of the dressing which serves to hold the fragments of bone and the joints in position must be such as to permit the wound and its neighborhood to be enclosed in a large securely occluding antiseptic dressing, in the beginning of treatment, and to allow the latter to be easily removed and re-applied at any time.

For this reason the simple slightly concave splints should be used at first — for instance, Volkmann's leg splint (Fig. 144), my wire splints (Figs. 283, and 284), the plastic splints (of pasteboard, felt, gutta-percha, Beely's plaster of Paris splints), or the position apparatus (Figs. 214 to 226).

The splints must be padded with cotton, or long, narrow cushions stuffed with antiseptic material (peat, moss, jute, wood fibre, etc.) which can be easily shifted by shaking, and covered with some water-proof stuff. The limb, antiseptically dressed, is firmly secured upon the splint with wet crinoline bandages.

The interrupted and stirrup plaster of Paris dressings (Figs. 177, seqq.) may also be employed in these cases if there is time to apply them.

It is also advantageous, especially in resections of joints, to include aseptic materials (glass splints, wood splinting, flower-pot trellis-work) between the layers of the antiseptic dressing, to stiffen it.

For compound fractures of the thigh and injuries of the hip-joint, extension by weights, in combination with removable splints (Figs. 243, seqq. page 119) forms the most suitable treatment — that is, in hospital. For transport, the weights must be replaced by an elastic extension (Figs. 249 to 253).

The **plaster of Paris dressing** is suitable only in the first stages of penetration fractures and ordinary gunshot fractures, in which it is desired to attempt antiseptic occlusion; but then an opening must be made in the splint at the proper time, so that the good condition of the wounds can be proved by examination.

The fenestrated and interrupted plaster of Paris dressings render excellent service in the later stages of the treatment of compound fractures, if the wounds have remained aseptic and are healing well, but the fractured ends have not yet firmly united — for union often takes place very late under antiseptic dressings.

THE REMOVAL OF FOREIGN BODIES FROM WOUNDS.

If the bullet has not passed entirely through the part of the body injured, but has remained in it, the wounded soldier is generally very anxious to have it removed, considers himself safe if this has been successfully accomplished, and rewards his physician with the greatest gratitude and thankfulness for its removal.

The removal of a ball which can be felt under the skin is by no means a difficult operation.

A bold incision is made with a sharp knife upon the ball, fixed by the left hand, until it becomes visible in the wound, when it is extracted with the dressing forceps or bullet forceps.

If the ball has been very much altered in shape, and has acquired projecting points and teeth, the cellular tissue and the fascia must often be divided in several directions in order to extract it without force.

Simple as this operation really is, and much as the young surgeon rejoices in its successful performance, and in the gratitude of the injured man, it is nevertheless unjustifiable to undertake it, according to our present opinions, unless it is possible to observe every antiseptic precaution, and this is as a rule impossible on the field of battle, and at the regimental dressing-station.

In former wars, this little operation, and also the examination of the wound, if undertaken immediately after its infliction, and with dirty instruments, have doubtless often been the cause of septic infection.

In future the first principle of medical treatment must also be observed on the field of battle — **at least do no harm!** — and the surgeon must refrain from this little operation, as well as from the examination of wounds with dirty fingers and instruments.

The **extraction of deep-seated projectiles** also presents no particular difficulty in modern times, for there is now no danger in freely dividing the soft parts if it is necessary.

In fresh cases, bullets found in the wounds are removed at once, when the wound is prepared for antisepsis, and no other instrument is required for this purpose than the ordinary dressing forceps.

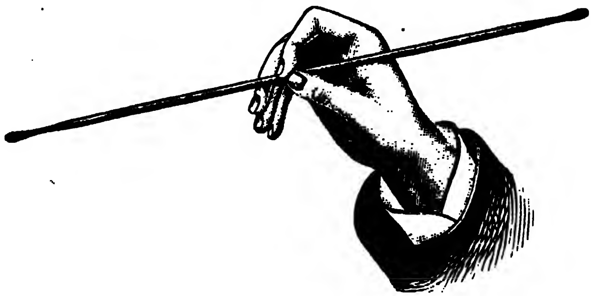
But if it is necessary to remove balls which are at the bottom of a healthy granulating wound, and cause delay in its final cicatrization, or maintain obstinate sinuses, or cause trouble by pressure upon nerve trunks or other important organs, the extraction may be very difficult, especially if the ball has been much altered in shape, lies in a dangerous position, or is firmly imbedded in some bone.

Sometimes the first question to be determined is, whether there is a foreign body in the bottom of the wound, and what the foreign body is.

If the finger can not reach the bottom of the wound, an attempt must be made to feel the foreign body with the probe. The

ordinary small silver probe, with which nothing can be accurately felt, and the fine point of which is apt to lead into false passages, should not be used for this purpose. Instead, a flexible tin probe, a foot long and in thickness from the size of a goosequill to that of the little finger (Fig. 303), should be employed, for, by delicate handling, no harm can be done with this instrument [1]).

Fig. 303.



Large probe.

These probes are also very useful for making counter-openings at the end of long suppurating fistulae, the end of which can not be reached by the finger or forceps. If it is desired to thoroughly disinfect these sinuses, a wiper wet with strong carbolic or chloride of zinc solution is fastened to the middle of a strong thread, introduced into the sinus by the probe, and drawn back and forth until all the granulations have been rubbed away (Fig. 304).

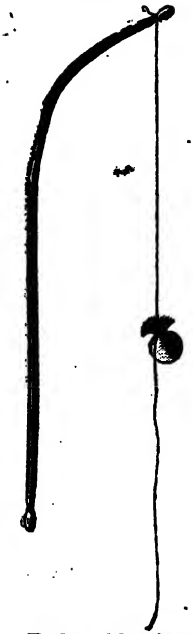
If the bullet is felt, an attempt must be made to seize it with a bullet forceps (Figs. 305 and 306), and to carefully extract it.

If it is imbedded in a bone, it can be removed with the aid of a bullet screw (Fig. 307). But if it is very securely wedged in the bone, too much force must not be used, because dangerous inflammation of the bone is liable to be set up in that way. It is better to wait quietly until the projectile becomes loose of itself, by inflammatory absorption of the bone; or, after sufficient division of the soft parts, to cut away enough of the surrounding bone with the chisel and mallet to allow of extraction of the ball by the forceps, without violence.

If there is doubt whether a hard body felt at the bottom of the wound is the bullet, the doubt may be removed either by the **bullet probe** of Nélaton (Fig. 308) the porcelain knob of which will

[1]) It is very dangerous to use the catheter which the dressing-case contains for these examinations, as I have frequently seen done in war. In the interior of this instrument there are generally infectious materials which have been left there from its previous use — in relieving retention of urine.

Fig. 304.



Probe with wiper attached.

Fig. 305.

von Langenbeck's bullet-forceps.

Fig. 306.

American bullet-forceps.

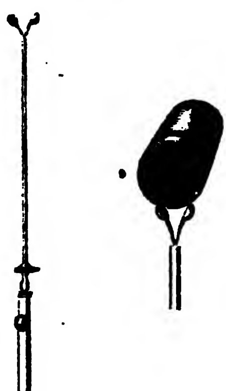
Fig. 307.

Bullet-screw of Baudens.

Fig. 308.

Porcelain bullet probe of Nélaton.

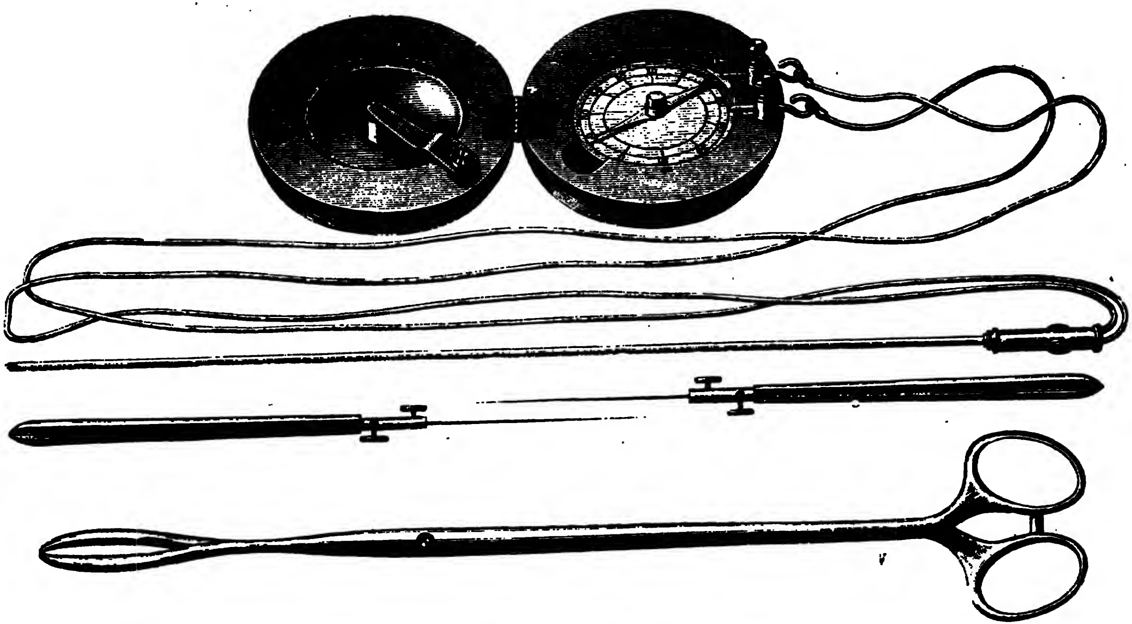
Fig. 309.



Bullet searcher of Lecomte-Lüer.

— 162 —

Fig. 310.



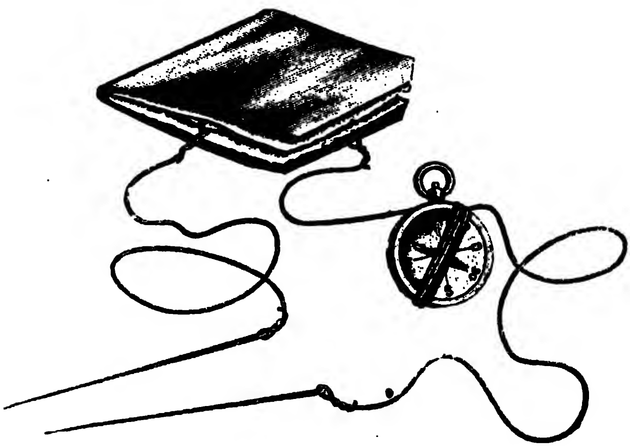
Liebreich's bullet searcher.

be marked with black if it is touched by lead[1]); or by the **bullet searcher** of Lecomte-Lüer (Fig. 309), with which a piece of lead can be gnawed from the ball; or, lastly, by the **electric bullet probe** of Liebreich (Fig. 310) which sets in motion the needle of a galvanometer whenever the two isolated ends of the probe (a), or the forceps (c) come in contact with a metallic body.

If the bullet can not be felt through the wound, but can be felt **under the skin** elsewhere, and if there is doubt whether what is felt is the ball, or a piece of bone, the diagnosis may be made by inserting two steel needles on handles (acupuncture needles, Fig. 310, b) which are connected with Liebreich's bullet searcher.

If the apparatus of Liebreich is not at hand, a similar one can be **improvised** (according to Longmore) out of a copper coin and a folded piece of sheet zinc, the two being separated by a piece of flannel wet with dilute acid. Two insulated copper wires are connected with acupuncture needles, and one of the wires is wound several times around a pocket compass, the needle of which will move whenever the circuit is closed by touching the ball (Fig. 311).

Fig. 311.



Longmore's bullet searcher.

If bullets are to be removed which have remained imbedded in the bone for years, or pieces of dead bone which lie in cavities in the bone (very frequent after osteo-myelitis in consequence of gunshot-contusion of the bone) the **bone cavity** must be **opened** (operation for necrosis).

[1]) In case of need the stem of a clay pipe can also be used for this purpose (von Nussbaum).

These operations can be most rapidly and conveniently performed with mallet and chisel, and the ordinary carpenter's chisels with handles are, in fact, much more useful than those supplied in surgical instrument cases (see Trephining).

At any rate, in the absence of the latter, the necessary instruments can be procured from any carpenter or turner.

The affected bone is exposed at a suitable place by a free incision in the skin, the thickened periosteum is pushed back on both sides with the raspatory (Fig. 312) and the cavity is opened by strong blows with the chisel until the dead bone is exposed, and can be drawn out with the sequestrum forceps (Fig. 313).

If it is only a projectile which has to be removed from a cavity in the bone, the fistula which leads through the wall of bone to the foreign body can be most rapidly enlarged with a reamer (Marshall's osteotribe) (Fig. 314).

Fig. 312.

Von Langenbeck's raspatory.

Fig. 314.

Marshall's reamer.

Fig. 313.

Sequestrum forceps.

In operations for necrosis, it is not sufficient merely to enlarge the fistula (cloaca) so as to barely extract the fragment of dead bone (sequestrum). There is then no certainty that smaller or larger sequestra do not remain in the corners and extensions of the bone cavity, which may subsequently make a repetition of the operation necessary.

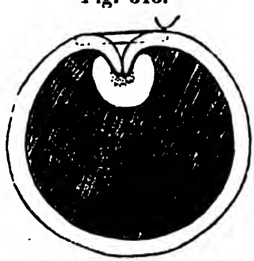
It is much better to chisel away the entire wall of the thickened bone forming the cavity, after exposing it, and to change the cavity into a large **open shallow groove**, so that no cavities in the neighborhood can escape discovery.

When the operation has been completed, the depression in the bone is stuffed with antiseptic gauze, or a firmly filled peat bag, a tight antiseptic dressing applied over it, and not until then is the elastic tube or constricting band, which has up to this time cut off the arterial blood supply, removed. The most extensive operations of this kind, formerly accompanied with great loss of blood, can thus be completed without the least hemorrhage, and if a rubber bandage is finally applied over the dressing, and the extremity is secured for some hours in a position of perpendicular elevation, very little blood (or none at all) will subsequently ooze from the injured vessels; and when the dressing is renewed after a period of some weeks, the cavity in the bone is usually already lined with healthy granulations.

In any case, however, it requires considerable time for the large and deep cavities of the wound to fill up with granulations, and for cicatrization to be complete.

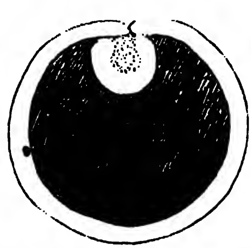
To hasten the healing process, the skin on both sides of the wound can be raised from the fascia for a distance of some centimeters, the flaps of both sides pushed into the cavity, and pressed firmly against the surface of the bone by a tightly applied dressing; or by a few short steel nails, which are driven through the skin into the bone; or by strong catgut sutures introduced through the folds of the skin flaps where they lie in contact (folding-in suture, Neuber) (Fig. 315).

Fig. 315.



Folding-in suture.

Fig. 316.



Bone cavity filled by new tissue.

The space between the flaps of skin which have been turned in is stuffed with crumpled gauze, peat-gauze, moss or sawdust, and the compressive dressing applied.

In this manner the entire extent of a large wound can sometimes be made to heal by first intention.

The cavity in the bone under the flaps of skin, which are at first deeply depressed, gradually fills up with newly formed bone,

raising the skin to its original level, so that the final result is the same as in the slow healing by granulation (Fig. 316).

If, in the antiseptic examination of a wound, it is discovered that **tendons** or **nerves** have been completely divided (as happens especially in large stab-wounds, or incised wounds) these must be at once united by suture.

SUTURE OF TENDONS.

If the ends of the divided tendons have retracted into their sheaths, they must first be drawn out with forceps, so that they can be made to over-lap for some distance. In doing this, the points of attachment of the muscles must be approximated as nearly as possible. The ends are united by sutures in this position (best with needles curved on the edge [Wolberg, Hagedorn] and chromic acid catgut) so that their lateral surfaces, which are richer in blood-supply than the cut surfaces, are in contact. After the wound in the skin has been sutured, a dressing must be applied which will relax the muscles of the injured tendons as much as possible (see, for example, Fig. 280).

SUTURE OF NERVES.

After the ends of the divided nerves have been approximated as much as possible by suitable position of the limb, the loose connective tissue around them is to be seized with forceps, and sutured on all four sides with fine catgut, so that the cut surfaces of the nerves are brought into exact contact (paraneural nerve suture).

If the injury to the nerve is an old one, the stumps, which are often widely separated, must be sought in the cicatrized wound and dissected free. A thin layer is then dissected from the end of the stumps, and the cut surfaces united by several fine catgut sutures, which are introduced with fine needles, curved on the edge, through the ends of the nerves themselves (direct nerve suture).

In this case, also, all tension upon the united ends must be relieved by the dressing.

TREATMENT OF INJURIES OF BLOOD-VESSELS.

(CONTROL OF HEMORRHAGE.)

Severe **hemorrhage** from fresh wounds directly threatens life, and must be stopped at once, preferably by **ligature** of the injured vessels. But if ligatures cannot be applied immediately as, for example, in the press of battle, there are various means for **controlling bleeding temporarily** (provisional arrest of hemorrhage) and first of these is:

DIRECT COMPRESSION OF THE WOUND

By the **pressure of the finger** or of the hand. In many cases this can be exercised by the wounded man himself. But pressure with the finger can not very well be continued for any length of time, therefore during transport of the wounded into hospital it should be replaced by:

A **dressing** which exerts sufficient **pressure** upon the wound. But before a **compressive dressing** of this kind is applied, if the injury has happened to an extremity, the entire limb must be carefully bandaged from below upwards, preferably with cambric bandages, in order to prevent dangerous extravasation of blood into the cellular tissue **(infiltration of blood).** A firm **pad** of antiseptic material (carbolized, iodoform, or bichloride gauze) is laid upon the wound, and is firmly pressed upon it by a tightly applied bandage, best of some elastic material (rubber bandage, elastic trouser-suspenders).

Fig. 317.

If there is an injury of an artery of some size, it is safer to **tampon** the wound itself — that is, to press with the finger the middle of a piece of bichloride or iodoform gauze as deep into the wound as possible, and to quickly and firmly stuff into the cavity (after the finger has been withdrawn) first small, then larger antiseptic balls, until the last extend far above the level of the wound in the skin (Fig. 317). The tampon is then firmly secured by a bandage — elastic, if possible. As soon as the wounded man has reached the hospital, the tampon should be removed, and the hemorrhage, in case it recommences, immediately and permanently arrested.

STYPTICS.

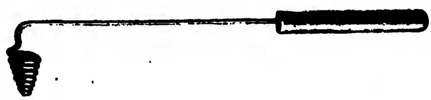
Styptics, that is, substances which act partly by favoring the coagulation of the blood and the contraction of the walls of the vessels, partly by forming a firmly adherent scab, should be employed only in cases of imperative necessity, when the hemorrhage can not be controlled by the tampon alone. For fresh wounds are generally greatly irritated, or even strongly cauterized by these drugs. In any case, they are useful only in combination with direct compression. Only such

styptics are to be used as have at the same time an antiseptic action, to these belong — **liquor ferri chloridi,** especially in the form of **styptic cotton** — cotton saturated with it, **tannin** (Graf), **creasote** as Aqua Binelli (1 to 100 water) **oil of turpentine** (Baum, Billroth), and **chloride of zinc** in concentrated solution. These substances are to be brought into as close contact as possible with the bleeding point, by first pressing a tampon saturated with the styptic into the bottom of the wound, and then proceeding as in making an ordinary tampon.

THE ACTUAL CAUTERY.

The actual cautery, which in earlier times enjoyed so great a reputation as a method of controlling hemorrhage, by no means deserves this reputation, for the slough caused by it is apt to be torn away again by the iron, if the latter is not white-hot. It is best suited for arresting parenchymatous hemorrhage, such as occurs with hospital gangrene, or after venous thrombosis — Stromeyer's phlebostatic hemorrhage. If no cautery irons are at hand, they can be easily extemporized (according to Brandis) out of a piece of telegraph wire, by twisting up one end into a spiral, and sharpening the other so that it may be stuck into a wooden handle (Figs. 318 and 319).

Fig. 318.



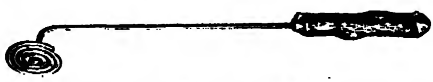


Fig. 319.

Cautery irons improvised from telegraph wire, according to Brandis.

COMPRESSION OF THE MAIN ARTERY.

Compression of the main artery above the wound by the finger **(digital compression)** can only be exercised at points where a hard support is furnished by the bone underneath. The most important places for digital compression are the following: —

For the **common carotid,** the anterior lateral region of the neck, between the larynx and the internal edge of the sterno-mastoid, where the finger compresses the artery against the vertebral column (Fig. 320).

For the **subclavian,** the supraclavicular fossa, in which, at the external edge of the sterno-mastoid, the artery can be pressed against the first rib, as it emerges from behind the scalenus. By pressing the shoulder and the clavicle forwards, the finger can reach the artery more readily (Fig. 321).

Fig. 320.

Digital compression of the carotid.

Fig. 321.

Compression of the subclavian.

By strongly drawing the shoulder backwards and down-wards with the aid of the other arm, it is also possible to depress the clavicle to such an extent that the subclavian artery will be flat-

tened by it against the first rib. The hand is to be passed behind the back and made to grasp the elbow of the uninjured arm, the latter is then pressed forwards, and both arms secured in this position by handkerchiefs or bandages (Fig. 322).

Fig. 322.

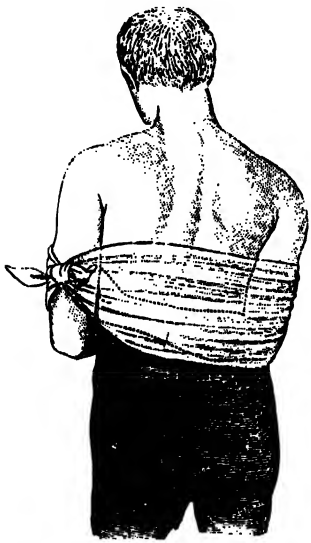


Fig. 323.

Digital compression of the brachial.

For the **axillary artery**, the anterior edge of the axillary fossa, where the artery can be compressed against the head of the humerus when the arm is elevated.

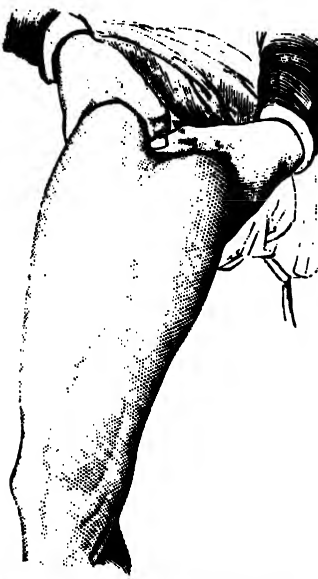
For the **brachial**, the internal side of the arm in its entire length, where the artery can be easily compressed at any point against the humerus, along the internal edge of the biceps (Fig. 323).

The **abdominal aorta** can be compressed against the vertebral column at the level of the umbilicus, when the abdominal walls are relaxed and the intestines empty. But generally the pressure can not be long endured without an anaesthetic.

The same is true of the upper part of the **external iliac** — which can be compressed against the lateral edge of the brim of the pelvis. It can be occluded more easily and for a longer time just before its exit from the pelvis, above the middle of Poupart's ligament, against the upper edge of the horizontal ramus of the pubic bone.

The **femoral artery** can be compressed with the greatest certainty directly below Poupart's ligament, against the ileo-pectineal eminence (Fig. 324). It will be found at the middle of a line drawn from the anterior superior spine of the ilium to the symphysis pubis.

Fig. 324.



Digital compression of the femoral artery.

Fig. 325.

Petit's tourniquet.

In its course below, it can be compressed against the femur as far down as the lower third of the thigh, but digital compression is difficult and uncertain on account of the thickness of the interposed soft parts — at least in fat or muscular individuals.

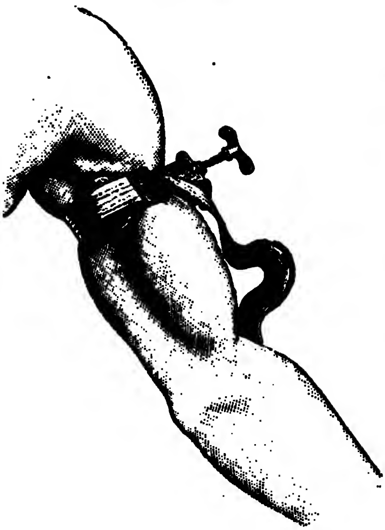
As only a skilful and strong hand can continue digital compression for a long time, and as it is impossible during transportation for any distance, attempts have been made to replace it by various means. Among these are: —

The **tourniquets**, the most useful of which is the **screw tourniquet** of Petit (Fig. 325), in which the pressure is exercised upon the artery by a pad, or rolled up bandage, and the amount of pressure can be regulated by a screw, and made as strong as desired (Figs. 326 and 327).

In the absence of such an instrument, a **stick tourniquet** can be extemporized by tying a pocket handkerchief or a three-cornered cloth, in which a hard knot has been tied or a stone wrapped up, around the limb, and winding this up tightly by twisting it around with a cane, or any short straight object (dagger, ramrod, revolver), passed under the cloth (Fig. 328).

For compression of the **brachial artery**, a proportionally lighter pressure will suffice — such as may be exerted by a stick against the internal surface of the arm (Fig. 329), pressing the bellies of the

Fig. 326.

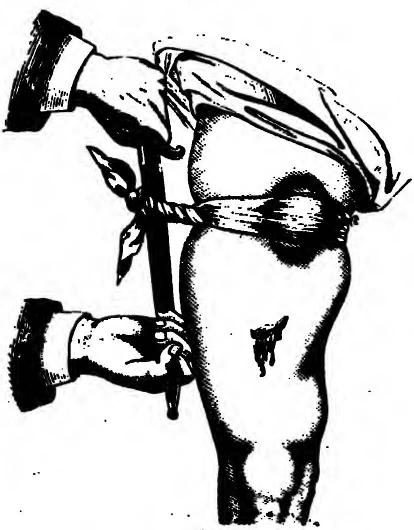


Compression of the brachial artery by a tourniquet.

Fig. 327.

Compression of the femoral artery by a tourniquet.

Fig. 328.



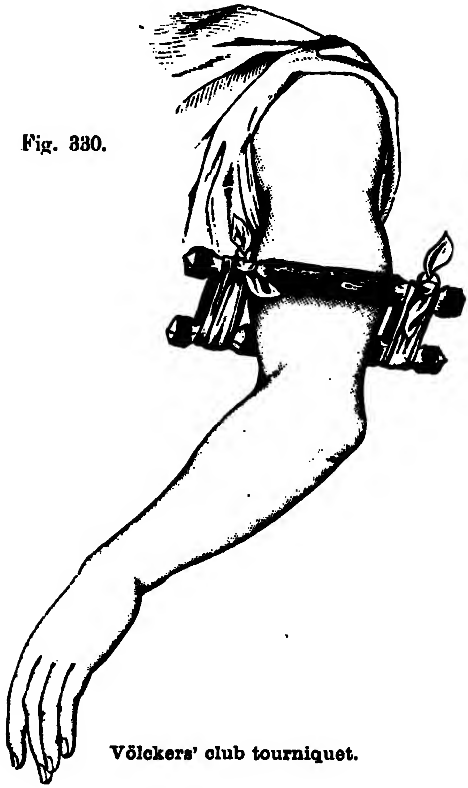
Improvised tourniquet.

Fig. 329.

Compression of the brachial artery by a piece of wood.

muscles apart in front and behind, and flattening the artery against the bone. The **club tourniquet** of Völckers, which fulfils this object, can be easily improvised from two sticks and two handkerchiefs (Fig. 330).

Fig. 330.



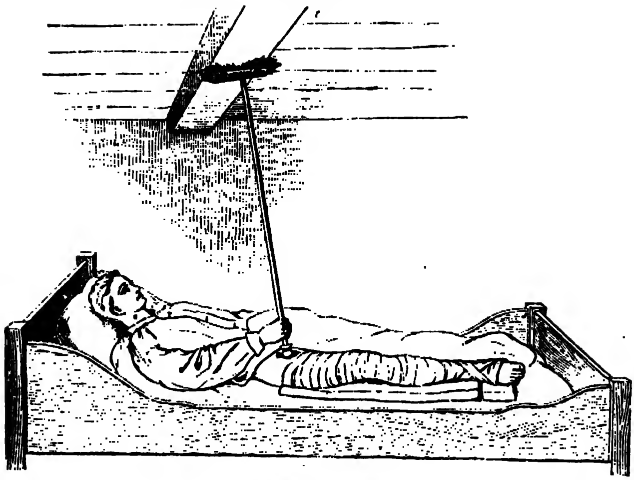
Völckers' club tourniquet.

When the patient is in bed, and compression of the **femoral artery** is to be maintained for a long time (aneurism), **pole pressure** can be employed. A pole (lath, broomstick, lance, or some similar object), the lower end of which has been wrapped with linen, is wedged in between the leg (in a position of outward rotation) and the ceiling of the room, so as to exert sufficient pressure upon the artery. The pole must be a little longer that the perpendicular distance between the ceiling and the point of compression (Fig. 331).

If the ceiling is too high, a crossbeam is placed over the bed and a crutch wedged against this (Fig. 332).

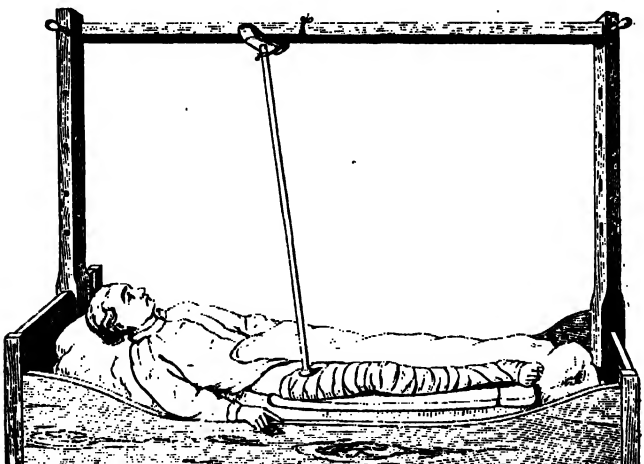
Finally, **forced flexion** of the limbs (Adelmann) is recommended as a means of controlling arterial hemorrhage — the artery being so

Fig. 331.



Pole-pressure
on the femoral artery, by means of a broom wedged against the ceiling of the room

Fig. 332.



Pole-pressure
by means of a crutch wedged against a cross-piece over the bed.

sharply bent that it will not allow the passage of the blood. If for example, in a case of arterial hemorrhage from the forearm, or the hand, the forearm (in supination) is strongly flexed, and tied tightly against the arm with a bandage or cravat, the pulse in the radial

ceases at once. In the same way, hemorrhage from the leg and foot can be instantaneously stopped by forced flexion of the knee; and that from the femoral by forced flexion of the thigh. In cases where other means of controlling hemorrhage are not available, this method can be successfully employed. But it is necessary to observe that the extreme position of flexion required for the reliable control of hemorrhage can not generally be endured for any length of time, and if at the same time the bones are fractured, it is impossible to make use of the method.

The surest, and at the same time the simplest method of cutting off the circulation is to **surround** the limb with an **elastic band** (rubber tube or bandage). If the limb is several times surrounded in one place with such a band, tightly stretched, and its ends are secured so that they can not slip, all the soft parts and the vessels contained in them will be so firmly compressed, that not another drop of blood can pass through. It is self-evident that an elastic band continues in action **permanently,** while the band of a tourniquet soon stretches, and lengthens, and loses in power. The elastic band, too, can be applied with effect **at any desired point;** its use therefore requires no accurate knowledge of anatomy.

With the aid of elastic bandaging, moreover, the blood can be completely removed from an entire limb, and if the arterial supply is then cut off, extensive and prolonged operations can be performed without the loss of any blood whatever.

THE BLOODLESS METHOD.

The bloodless method[1]) is applied as follows:

1. After any wounds which may be present have been well covered with cotton and water-proof material (varnished paper), the entire limb is **firmly bandaged** with **elastic** bandages from the ends of the fingers or toes upwards to a point **above the site of operation,** so that the blood is almost completely driven from the vessels.

2. Where the bandage ends, a **rubber tube** (constricting tube) is wound several times around the limb, with moderate tension, so that **the arteries shall not permit the passage of any more blood.** The ends of the tube are fastened together by a knot, or by a hook and chain (Figs. 333 and 334).

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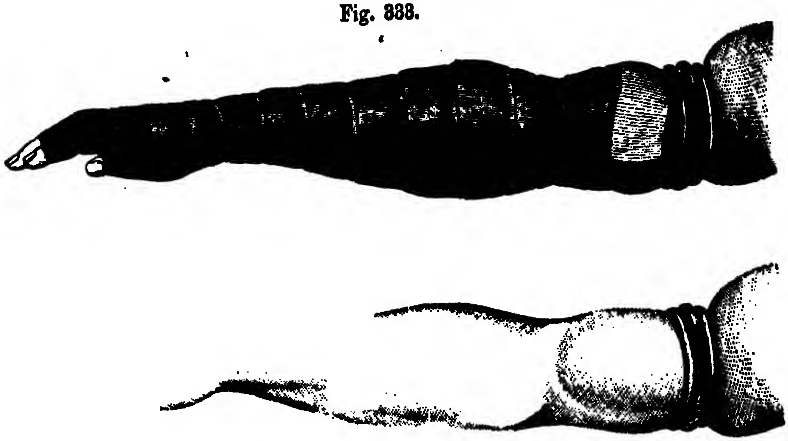
[1]) This method, which I have named „the **artificial bloodless method**" (bloodless operation, blood-sparing method, temporary ischaemia) has been employed in all amputations, and taught by me since 1855. But it was not until 1873, after I had begun to make use of the elasticity of rubber for cutting off the arterial supply, as well as for emptying the vessels, that I conceived the idea that it could be employed with advantage in **all** operations upon the extremities involving loss of blood. (See Volkmann's Sammlung klinischer Vorträge, No. 58, Leipzig, 1873.)

Fig. 333.

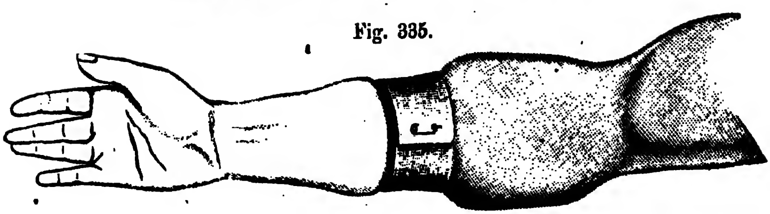


Esmarch's apparatus for the bloodless method.

Fig. 334.

Esmarch's apparatus for the bloodless method.

Fig. 335.



Rubber constricting band.

3. In most cases the arteries can be completely occluded by a **rubber bandage** (constricting bandage) firmly applied in several circular turns and then secured by a safety pin (Fig. 335).

4. If the first rubber bandage is then removed, the limb will present a pale, **completely cadaveric hue**, and any operation can be performed upon it **without loss of blood**, exactly as upon the cadaver, even if the operation be very tedious. Experience has taught that an extremity, and even two extremities at once, can be kept deprived of blood for several hours without injury.

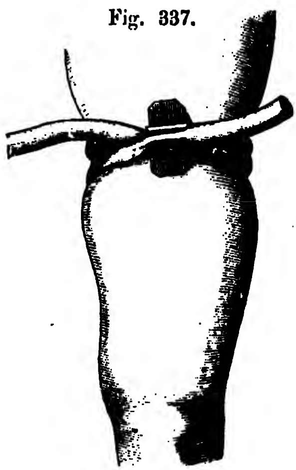
5. But parts which contain **pus**, or **decomposing matter**, should not be firmly bandaged in this way, because infectious matters might thus be driven upwards into the cellular tissue, and the lymph channels. In these cases it must suffice to elevate the limb perpendicularly for some minutes, so as to diminish the amount of blood in the vessels before the constricting tube is applied.

6. Instead of the chain-fastening, a **clamp** can be employed to secure the ends of the tube, as for example, a split ring of the same diameter as the tube in use, the slit being large enough to allow the **stretched** ends of the tube to enter easily. When the tension is relaxed, both ends of the tube are firmly wedged in opposite directions (Figs. 336 to 339).

Fig. 336.

Esmarch's brass clamp for the constricting tube.

Fig. 337.

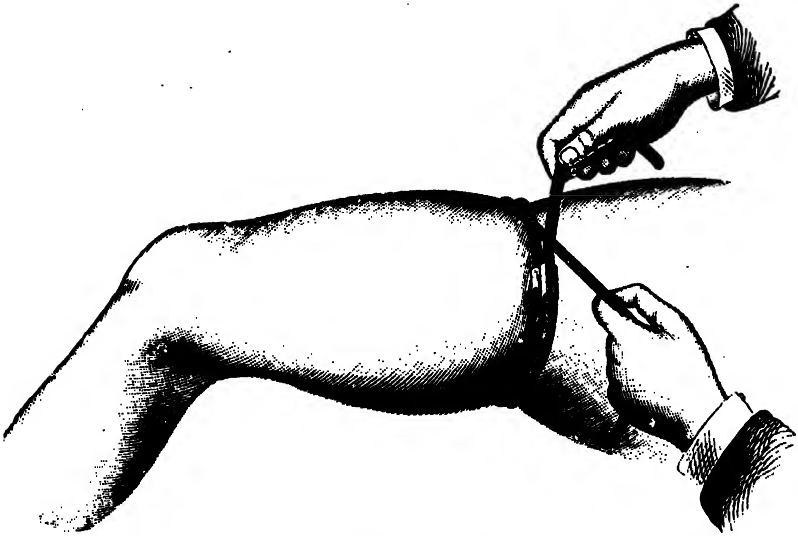


Esmarch's clamp in use.

Fig. 338.

Foulis' clamp, for a solid rubber band.

Fig. 339.



Foulis' clamp in use.

7. To secure the **constricting band,** the arrangement invented by Nicaise can be employed. It is a rubber band, at one end of which a hook and a number of rings are sewed in a row (Fig. 340).

Still simpler is a **clamp buckle,** such as is in common use on trouser-suspenders and on cravats (see Fig. 354).

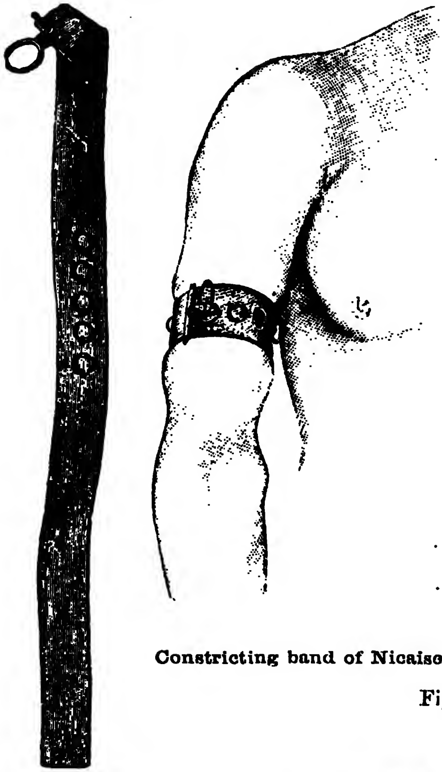
8. For the constriction of a finger, a rubber tube the size of a goose-quill will answer — applied as represented in Fig. 341.

9. With a similar tube, the root of the penis and scrotum can be constricted, if it is desired to perform operations on the **male genitals** without loss of blood (Fig. 342).

10. In **disarticulations** and **resections** of the **shoulder,** after the tube has been passed under the axilla and strongly stretched, the ends must be held above the shoulder, over the spine of the scapula, by a strong hand (Fig. 343), or by a tube clamp (Fig. 344). By drawing the ends towards the neck, all danger that the tube will slip off can be avoided.

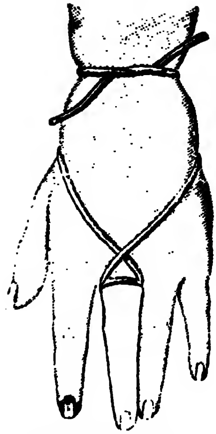
11. In **high amputations of the thigh,** the tube is tightly wound once or twice around the limb just below the flexure crease of the thigh, the ends are crossed above the groin, passing around over the posterior surface of the pelvis, and are finally hooked together by the chain across the abdomen (Fig. 345).

Fig. 340.



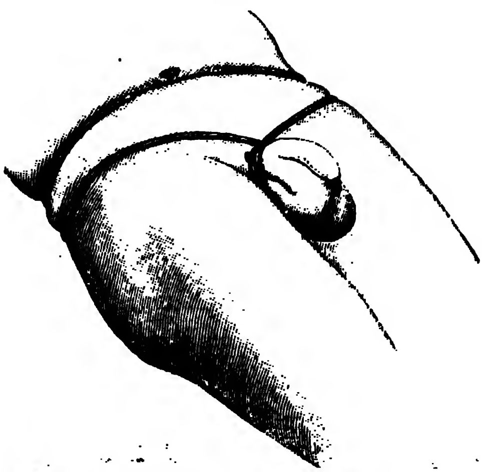
Constricting band of Nicaise.

Fig. 341.



Bloodless finger.

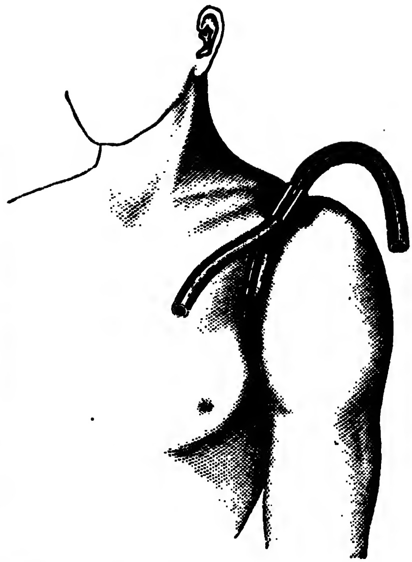
Fig. 342.



Elastic constriction of penis and scrotum.

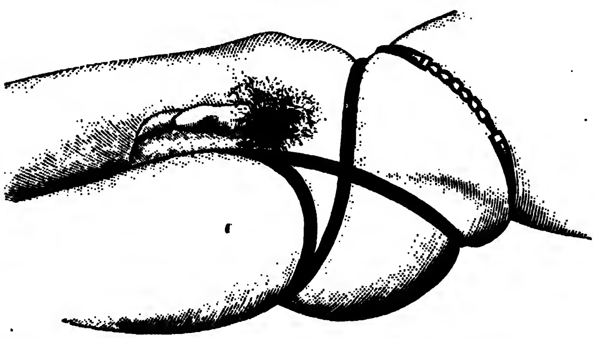
Fig. 343.

Fig. 344.



The bloodless method in disarticulation at the shoulder-joint.

Fig. 345.



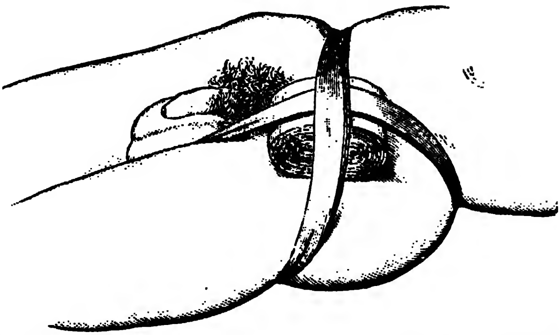
Bloodless method in high amputation of the thigh — with rubber tube.

12. A firmly rolled linen bandage may also be laid over the iliac artery, directly above Poupart's ligament, as a pad, and tightly pressed upon the artery by several figure-of-eight turns of a strong rubber bandage (Fig. 346).

13. In **disarticulations** and **resections** of the **hip**, if the intestines have previously been properly emptied, the arterial blood-supply

can be most certainly controlled by compression of the aorta in the umbilical region.

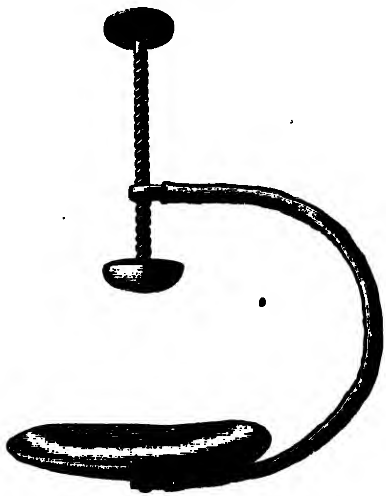
Fig. 346.



Bloodless method in high amputation of the thigh -- with pad, and rubber bandage.

14. For this purpose the **aorta tourniquet** of Pancoast can be employed — the pad of which is moved towards the support for the back by a long screw (Fig. 347), or —

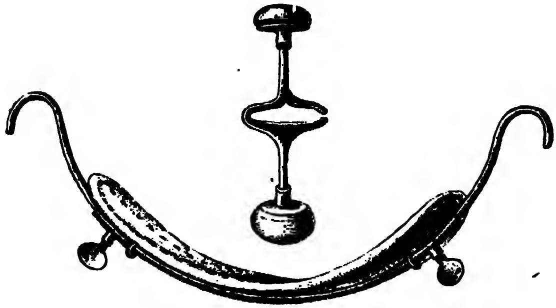
Fig. 347.



Pancoast's aorta tourniquet.

15. The compressor of the author (Fig. 348), the pad of which, mounted on a stem, is pressed against the vertebral column by elastic bandages which are stretched between the adjustable hooks of the

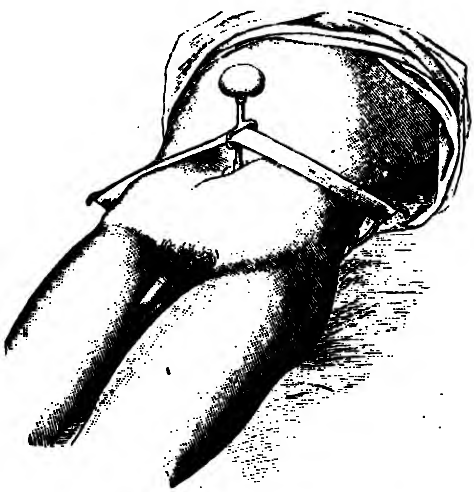
Fig. 348.



Esmarch's aorta compressor.

back-piece. The steel stem of the pad is provided with a slit through which the turns of the rubber bandage can be passed, and there are two pads of different sizes on the stem; the pad which is directed upwards is steadied by the hand of an assistant, so that the lower pad shall not slip from its position over the aorta (Fig. 349).

Fig. 349.

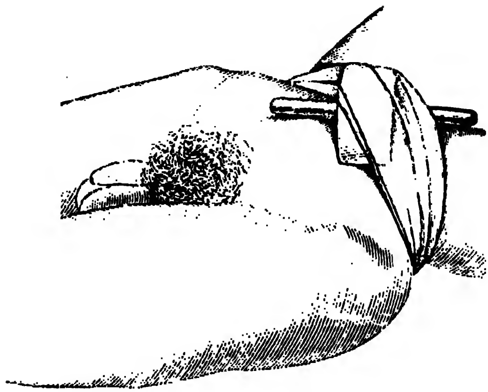


Esmarch's aorta compressor applied.

16. If there is no compressor to be had, a pad can be improvised by winding a linen bandage, 9 yards long, and $2^1/_2$ inches wide, tightly around the middle of a stick, as thick as the thumb and about a foot long. This pad is placed directly below the navel, held in the proper position by an assistant, and pressed against the vertebral column

by turns of a rubber bandage $2^1/_2$ inches wide, carried five or six times around the body (Fig. 350).

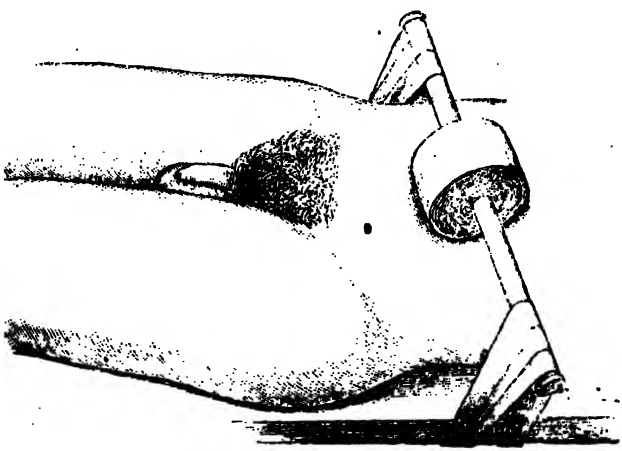
Fig. 350.



Improvised aorta compressor.

17. If it is desirable to avoid circular compression of the abdomen, the linen bandage is to be wound upon the middle of a longer stick, and the ends of the latter are pressed downwards by turns of a rubber bandage which are carried under the top of the operating table (Brandis) (Fig. 351).

Fig. 351.



Compression of the aorta, according to Brandis.

If the constricting band is loosened after the completion of the actual operation, without previously ligating the vessels, considerable hemorrhage follows at once, because the walls of the blood-vessels have been paralyzed by the continuous pressure on the vaso-motor nerves.

The bleeding is naturally most severe when the constricting band is loosened **gradually,** because the blood at once enters the arteries of the part which has been constricted, but cannot immediately return through the veins as they are still compressed.

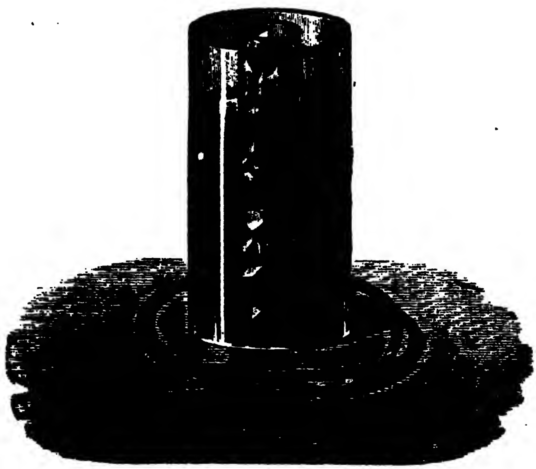
Therefore in every case the constricting band should be removed **quickly.**

But loss of blood can be entirely avoided, or at least limited to a very small quantity, if, before removing the constricting band, all the divided vessels are ligated (as described on pages 12 and 13), and the band not loosened until the wound has been closed by sutures, and a good compressive dressing has been applied. On this account the band must be applied as high as possible above the site of operation, so that there may be abundance of room for the application of the antiseptic compressive dressing.

The best means to prevent subsequent hemorrhage or oozing of blood is the vertical elevation of the limb upon a proper support, and this is to be continued for several hours after the operation.

If the surgeon does not dare to close the wound before the constricting band is removed, from fear of secondary hemorrhage, he must be prepared for the **subsequent parenchymatous hemorrhage,** which, even when the principal vessels have been already ligated, usually appears after the band has been removed, and during the first few minutes

Fig. 352.



Ice-douche.

overflows the entire surface of the wound. It is best controlled — first, by elevating the entire limb vertically, and exerting strong pressure upon the closed flaps (in amputations), for some minutes, with a large sponge; and secondly, by directing a cold disinfecting stream of water upon the whole surface of the wound. For this purpose, the ice-douche is employed — that is, a glass irrigator containing a weak antiseptic solution, in the middle of which is placed a cylinder of sheet metal filled with pounded ice and salt (Fig. 352).

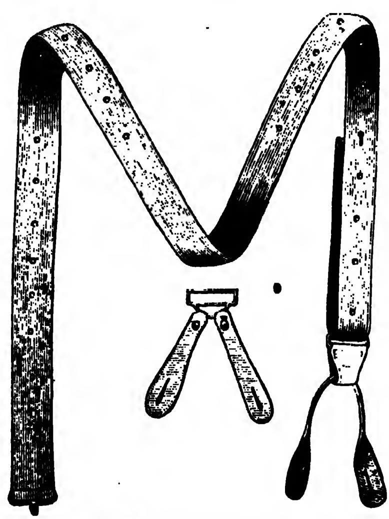
While the stream is playing, the small vessels which are still bleeding are easily seen, seized with clamp-forceps, and ligated as already described.

The subsequent parenchymatous hemorrhage can also be diminished by compression of the main artery.

Although elastic constriction acts much more securely, and is much easier to employ than the old tourniquet, still the latter could not be excluded from the supplies of surgical material for the troops, because india-rubber can not be kept in storage long without losing its elasticity in whole or in part.

In 1881, therefore, I proposed a trouser-suspender, which consists of a rubber band 5 feet long, and stout enough to compress the femoral artery of a strong man (Figs. 353 and 354).

Fig. 353.



Suspender-tourniquet.

This band can be used, not only for controlling the hemorrhage from injured arteries, but also as a ligature for poisoned wounds, and

Fig. 354.

Application of the suspender-tourniquet.

as a bandage for auto-transfusion to revive those dying of hemorrhage (See Fig. 397).

At that time I expressed the wish that every soldier should be provided with a suspender tourniquet of this kind in war.

Fig. 355.

Constricting band of metal spiral springs.

But as difficulties stood in the way of the general introduction of this suspender, I have had a **constricting band** made of **metal spiral springs**, covered with glove-leather, and provided with a catch similar to the clamp buckles of the Römpler suspenders and cravats (Fig. 355).

As I have no doubt but that this band can be kept for many years without losing its elasticity, I hope that it will finally displace the unreliable tourniquet.

THE PERMANENT ARREST OF HEMORRHAGE.

If a wounded man is brought into hospital with a dressing already applied, if it is supposed that an important vessel has been injured, because severe hemorrhage took place immediately after the wound was received, but not much blood has oozed through the antiseptic dressing applied directly after the injury, or if the hemorrhage does not recommence when the dressing is removed, no operative proceeding is to be undertaken at first, but rest and elevation of the limb only are to be employed, and every sort of constriction — by bandages, tourniquets, and so on, is to be avoided. Even injuries of large vessels may heal spontaneously, if there is no suppuration of the wound.

But such patients should be watched as continuously as possible, and the watcher should be instructed how to act in case of a sudden return of the hemorrhage.

If hemorrhage which is at all profuse, begins again, there should be no delay in immediately exposing the bleeding vessel at the point of injury, and ligating it directly in the wound.

DIRECT LIGATURE.

Before undertaking to find the injured vessel in the bottom of the wound, often a very difficult task, the relations of the vessels to the muscles, etc., must always be first called to mind. The following anatomical plates are intended for this purpose (Figs. 356 to 360).

The most important requirement for the **easy, quick,** and **thorough** performance of these operations, is a **large incision in the skin, extending upwards and downwards from the wound, in the longitudinal axis of the limb, so as to correspond with the course of the injured vessel. Where it is a matter of life and death, it makes no difference whether the incision be one inch or one foot in length; if the bleeding can be arrested, and the wound remains aseptic, the large incision will heal as well and quickly without suppuration as a smaller one.**

In other respects, the method of procedure is in this case just the same as has been described in speaking of secondary antisepsis (page 150). After sufficient division of the skin, the left forefinger is

Fig. 356.

Arteries of the head, neck, and axilla.

thrust into the bottom of the wound, the deeper layers — the cellular tissue, the fascia, and the muscles, are laid open upon it with a probe-pointed knife to the same extent, and the divided parts are held open with large sharp or blunt hooks.

Then with fingers, wipers, and sponges, the blood-clot which fills the whole cavity of the wound (the so-called diffuse traumatic aneurism) is quickly and thoroughly removed, and in the bottom of the wound will generally be found the injured vessel, or at least a cord of tissue infiltrated with blood, in which artery, veins, and nerves lie together. An attempt must be made to separate these different structures by careful dissection.

The discovery of the injured vessel will be rendered considerably easier by the use of the bloodless method. But if the veins are entirely empty of blood and collapsed, it may be difficult to distinguish

Fig. 357.

Arteries of the thigh.

them from strands of cellular tissue. It is therefore advisable to form **a reservoir of blood** below the wound — when, for example, there is an injury of the arm, apply a constricting band around the wrist before applying the elastic bandage to the arm. If this band is afterwards removed and the arm elevated, the blood which has been confined in the hand fills the veins, and if one of them be injured, makes its escape at the injured place.

When the injured point of the artery or vein has been found and exposed, so that the entire extent of the injury can be inspected, the vessel must be isolated, and firmly and securely ligated in the

Fig. 358.

Arteries of the arm.

Fig. 359.

Posterior.

Fig. 360.

Anterior.

Arteries of the leg.

healthy part above and below the injury, with catgut or antiseptic silk (square knot). Then, if the continuity of the vessel has not been already interrupted by the injury, it should be cut between the two ligatures, and the operator should assure himself that there are no branches given off from the vessel below or laterally, between the ligatures. If any such branches are found, they must also be well isolated, ligated, and separated from the main stem. In order to be quite secure, the injured part of the vessel, lying between the two ligatures, can be cut away.

The constricting tube (or bandage) is now removed, and every vessel from which the blood still escapes is carefully ligated, and while doing this the limb should be elevated, as in amputations after removing the tube, in order to diminish the parenchymatous hemorrhage.

LIGATURE OF THE ARTERY IN ITS CONTINUITY ABOVE THE WOUND.

(INDIRECT LIGATURE OF HUNTER.)

Ligature of the artery above the wound is only indicated in traumatic hemorrhage when an attempt at direct ligature does not appear advisable — for instance, if the wound itself has cicatrized, but a traumatic circumscribed aneurism has formed at the bottom of it, at a point where its exposure would render necessary a much severer operation than the ligature of the artery above in its continuity: or if it is desirable not to disturb a wound which is healing nicely after an amputation or resection.

The following rules should govern the search for the main arteries and their ligature:

1. Before beginning the operation, the surgeon must call to mind the exact anatomical relations of the point of ligature.

2. The direction and the length of the incision must be regulated according to these anatomical relations. It is well to indicate the incision beforehand with a stroke of india ink or a lead-pencil (Fig. 361).

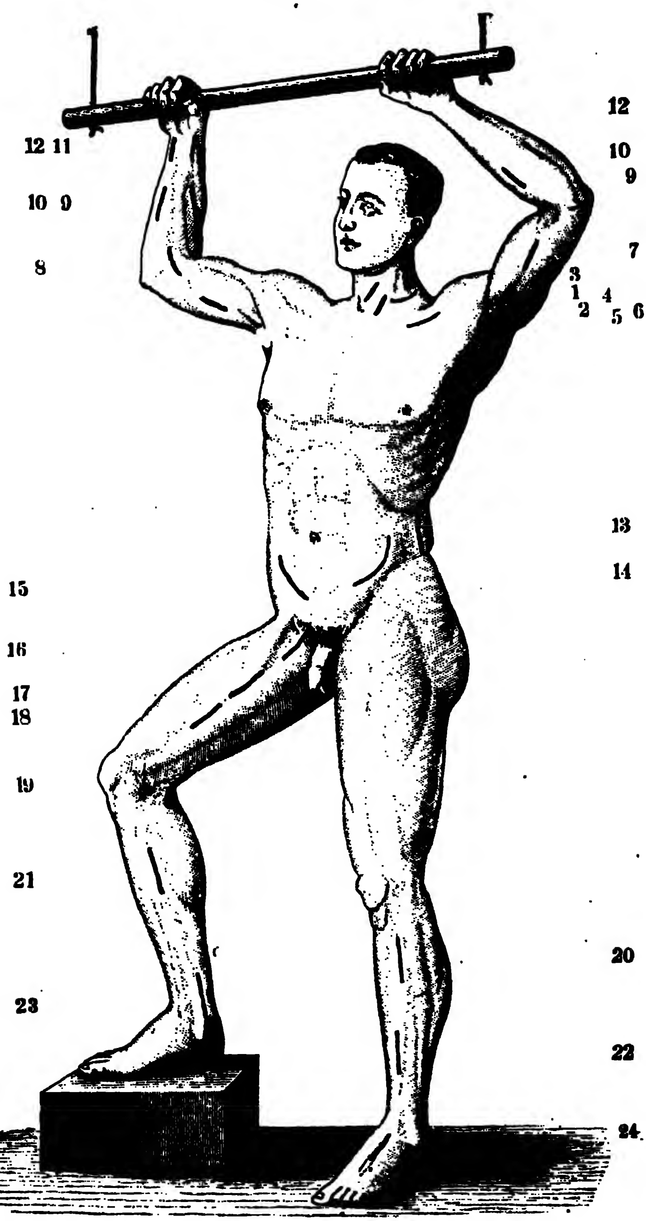
3. The part of the body upon which the operation is to be performed, must be placed in the most advantageous position, and in the best light for operation.

4. If the operation is to be performed upon an extremity, it is advantageous to previously make this bloodless, with the blood-reservoir modification described above for use in the operation for direct ligature. As soon as it is important to feel the pulsation of the artery, the upper constricting band is removed.

5. The **incision in the skin** is made **free-hand**, by stretching the surrounding skin with the left hand, and making the knife penetrate the entire thickness of the skin for the whole length of the incision (Fig. 362); or, if the artery or other important parts lie directly beneath the skin, by lifting up a **transverse fold** and dividing it with a stroke of the knife (Fig. 363).

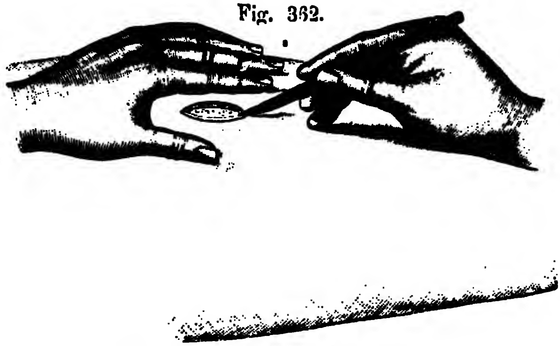
6. To penetrate with care to the deeper parts, the operator and his assistant seize the uppermost layers of cellular tissue with two good forceps, on each side of the line of the incision, and lift it up together, so that air enters its meshes (emphysema). A stroke of the knife divides the tissue which has thus been raised (Fig. 364).

Fig. 861.



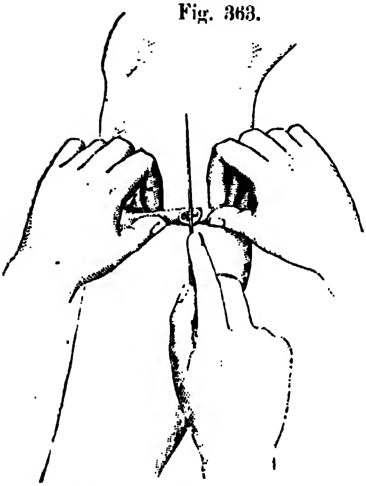
Incisions for ligature of the arteries.

Fig. 362.



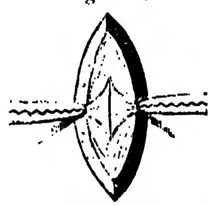
Incision in the skin, made free-hand.

Fig. 363.



Making the incision on a fold of skin.

Fig. 364.



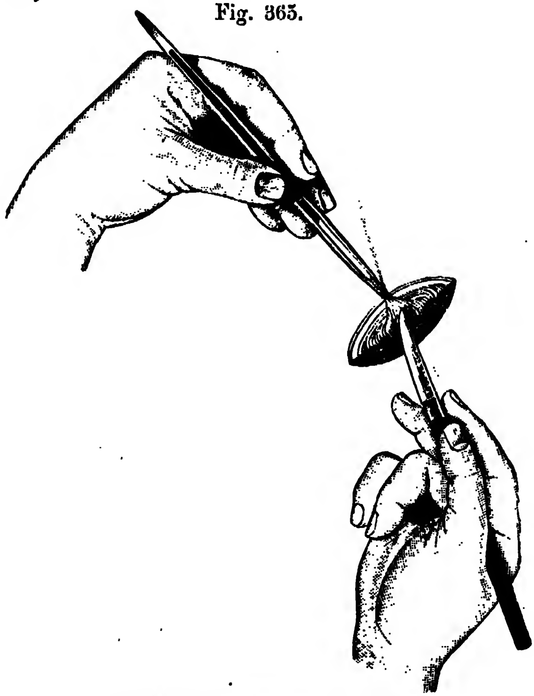
Dividing the cellular tissue between two forceps.

7. The two forceps then release it, and take fresh hold of the layer of cellular tissue in turn above and below the cut thus made, and lift it against the edge of the knife, which divides the fibres until the layer has been divided from one angle of the wound to the other. This method is applied to the subsequent layers, until the **sheath of the artery** has been reached. Any small veins, arteries, nerves, and muscles which lie in the way, are isolated and drawn aside with hooks.

8. As soon as the **sheath of the artery** has been exposed, the operator seizes it with his forceps over the middle of the wall of the artery, lifts the cellular sheath from it in a little fold, depresses the handle of his knife sideways, away from the wound, so that the side of the blade is turned towards the artery, and the point (at right

angles to the point of the forceps, and below it) penetrates the uplifted fold (Fig. 365).

Fig. 365.



Opening the sheath of the artery.

A small cut opens the **sheath**, and while the forceps raises the triangular flap made in this way, the point of the knife carefully separates the sheath from the wall of the artery.

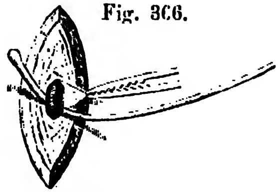
9. In arteries of considerable size, the operation is continued as follows: The operator, still holding the flap firmly with his forceps, introduces a second forceps, (closed) with his right hand, into the opening between the artery and the cellular sheath at the base of the flap, seizes the inner wall of the cellular sheath at this point, and draws it out. In this way the artery is gently rotated, and the fibres of connective tissue which unite the sheath to the lateral and posterior walls of the artery come into view, and are divided in the same careful way, and only to the extent of the original opening.

NB. If the sheath of the artery is separated from it for too great a space, the artery may become necrotic, and secondary hemorrhage will follow from the point of ligature.

In the largest arteries, when one half of the circumference has been separated, the same proceeding must be carefully carried out on the other side.

10. As soon as the artery has been isolated in its entire circumference, a **curved probe** (or a blunt hook) is carefully passed around the vessel, beginning on the side upon which the principal vein lies, while the forceps makes the cut edge of the cellular sheath tense (Fig. 366).

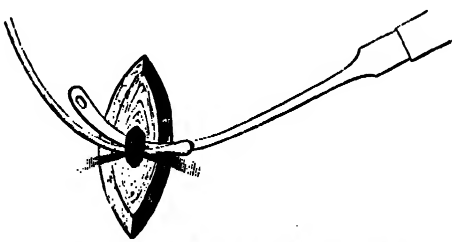
Fig. 366.



Introduction of the probe.

11. The artery is lifted by the probe so as to allow a small **aneurism needle**, with an eye at the point (Cooper's or Syme's) to be passed through, below, and in the opposite direction to that taken by the probe (Figs. 367 and 369).

Fig. 367.



Introduction of the aneurism needle.

12. The probe is removed, a stout **catgut thread** passed through the eye of the needle, and the latter withdrawn, leaving the middle of the thread lying under the artery.

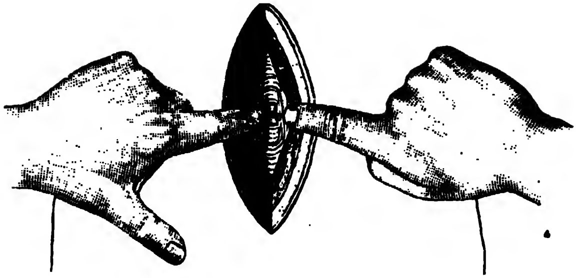
13. The **ligature** is tied around the artery with a **square knot** (see Fig. 24) (not the **granny knot**, see Fig. 25) and without pulling on the artery; the **knot must be drawn tight by the points of the two index fingers placed in the bottom of the wound** (Fig. 369).

Fig. 368.

Syme's aneurism needle.

14. It is advisable to ligate large arteries with two ligatures, and to cut through the vessel between them, so that both ends can retract into the cellular sheath.

Fig. 369.



Tying the ligature.

DIRECTIONS FOR THE LIGATURE OF THE INDIVIDUAL ARTERIES.

LIGATURE OF THE LEFT COMMON CAROTID AT THE LEVEL OF THE CRICOTHYROID LIGAMENT (Fig. 370).

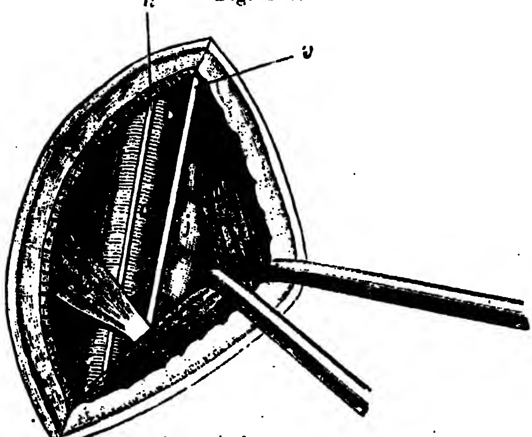
1. **Bend the head backwards,** by putting a **cushion under the shoulders.**

2. **Incision** $2^{1}/_{2}$ inches long, along the **internal border** of the **sterno-mastoid,** beginning at the **level** of the **upper edge** of the **thyroid cartilage** (Fig. 361, 1).

3. **Divide** the **platysma** and the cellular tissue (avoiding the superficial veins).

4. Draw the sterno-mastoid (st) **outwards,** the **omohyoid** (o) **downwards.**

Fig. 370.



5. **Draw** the descending branch of the **hypoglossal nerve** (h), which courses downwards **upon** the artery, **outwards.**

6. **Open** the common **cellular sheath over the middle of the artery.** The artery (c) lies **internally,** the internal jugular **vein** (j) **externally** and somewhat superficially, the **pneumogastric nerve** (v) between the two and deeper.

7. The aneurism needle is to be passed around the artery from the **outer side.**

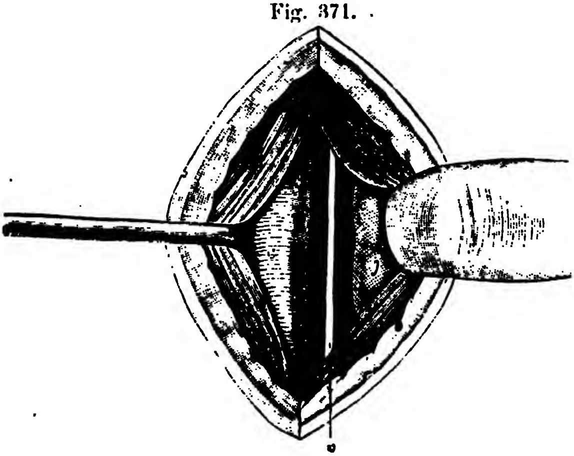
LIGATURE OF THE LEFT COMMON CAROTID BETWEEN THE TWO HEADS OF THE STERNO-MASTOID (Fig. 371).

1. **Incision** 2½ inches long, between the two heads of the sterno-mastoid, downwards to the clavicle, 1 inch external to the sterno-clavicular articulation (Fig. 361, 2).

2. **Divide** the **platysma;** open the **space** between the sternal and clavicular portions of the sterno-mastoid **with the fingers,** until the internal jugular vein (j) comes in sight.

3. Have the **vein** and the **clavicular head** (cl) held carefully to the **outer side** by the finger of an assistant, and the **sternal head** (st), with the sterno-hyoid and sterno-thyroid muscles, drawn **inwards.**

Fig. 371.



4. **Internal to the vein,** appears the **pneumogastric nerve** (v); the artery (c) lies somewhat to the inner side and deeper.

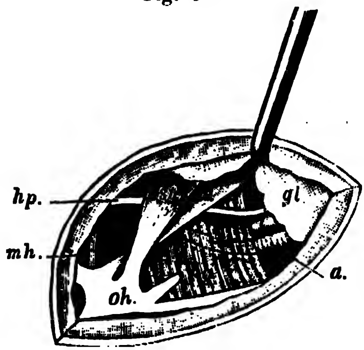
LIGATURE OF THE LINGUAL ARTERY (Fig. 372).

1. **Incision,** 2 inches in length, along the **superior edge of the great cornu** of the **hyoid bone** (Fig. 361, 3).

2. **Divide** the **platysma;** draw the **facial vein outwards.**

3. **Isolate** the **posterior belly** of the **digastric** (d), and the **hypoglossal nerve** (hp) will appear **behind** and **below** it; draw the submaxillary gland (gl) **upwards,** the great cornu of the hyoid bone **downwards** and **forwards** with sharp hooks.

Fig. 372.



4. The **hypoglossal nerve** passes across **in front of** the **hyoglossus muscle** (hg), accompanied by the lingual vein; **below** the nerve the **lingual artery** (a) passes **behind** the **hyoglossus muscle.**

5. **Divide** the **fibres** of the **hyoglossus** carefully, **between the hypoglossal nerve** and the **great cornu** of the **hyoid bone** (oh). The **lingual artery** lies immediately behind, accompanied by a vein.

The artery can also be ligated in the **submaxillary** (digastric) **triangle,** between the posterior belly of the digastric muscle, and the lateral edge of the mylo-hyoid muscle (mh) after division of the hyoglossus muscle (Hueter).

LIGATURE OF THE LEFT SUBCLAVIAN IN THE SUPRACLAVICULAR FOSSA (Fig. 373).

[The artery appears from behind the scalenus anticus (sc), and courses over the first rib (I.) downwards and outwards behind the clavicle.]

1. Place a cushion under the back; draw the **arm downwards** and the **head** to the **opposite side.**

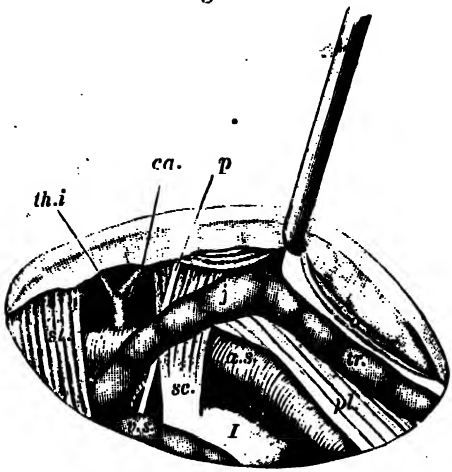
2. **Incision** $2^1/_2$ to 3 inches long, curved, from the outer margin of the sterno-mastoid to the outer third of the clavicle, crossing the supraclavicular fossa obliquely (Fig. 361, 4).

3. Cut through the **platysma,** and **expose** the **external edge** of the **sternomastoid** (st); the external jugular vein (j) must not be injured.

4. **Divide** the superficial layer of the **cervical fascia,** and of the fatty cellular tissue in the supraclavicular fossa.

5. **Isolate** the **omohyoid muscle** (o), and **draw** it **upwards.**

Fig. 373.



6. Dissect through fat and cellular tissue (with veins) to the scalenus (sc), the tendon of which can be felt near the tubercle of the first rib.

7. The internal edge of the brachial plexus (pl) appears, and must be drawn upwards and outwards.

8. Between the scalenus and the brachial plexus, but somewhat deeper than the latter, lies the artery; it will come into sight after division of the deep layer of the cervical fascia.

9. The subclavian vein (vs) lies in front of and below the tendon of the scalenus, and directly behind the clavicle.

NB. Avoid injury to the external jugular vein (at the outer edge of the sterno-mastoid), the suprascapular artery (near the clavicle), the transversalis colli (upon the brachial plexus), and the phrenic nerve (p), which courses downwards upon the scalenus.

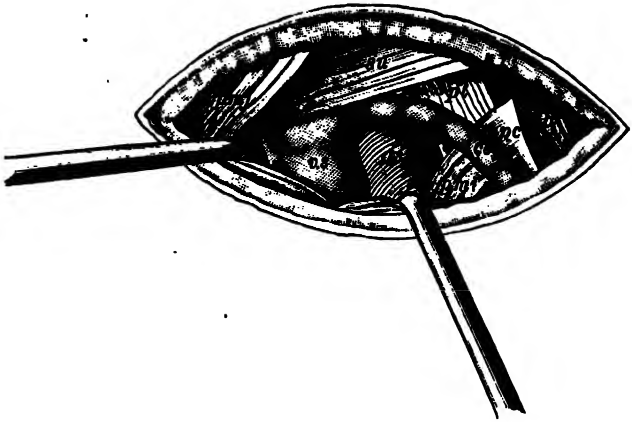
LIGATURE OF THE LEFT SUBCLAVIAN IN THE INFRACLAVICULAR FOSSA (Fig. 374).

1. Press the **shoulder upwards.**

2. **Incision** $2^1/_2$ to 3 inches long, beginning at the **coracoid process, parallel** with the **external half** of the clavicle (Fig. 361, 5), **exposing** the **triangular interval** between the deltoid and the pectoralis (**triangle** of **Mohrenheim**) through which the **cephalic vein** passes to **join** the subclavian.

3. **Draw** the **cephalic vein** (ce) and the edge of the **deltoid muscle** (d) **outwards**, the edge of the **pectoralis major** (pmj) (which **may** if **necessary** be separated somewhat from the clavicle) **inwards.**

Fig. 374.



4. After **division** of the **fatty cellular tissue** the **coraco-clavicular fascia** appears **beneath,** and is to be carefully **incised.** The **external thoracic artery** will generally require ligature.

5. The **pectoralis minor** (pmi), then appears, its **internal** (superior) **edge** forming an **angle,** open internally, with the **subclavian muscle.** Deep in this angle lies the **artery** (as), **between** the **brachial plexus** (pl), and the **subclavian vein** (vs), the **vein** lying on the **inner** side, the **nerves** on the **outer.**

NB. The pectoralis minor can be detached from the coracoid process (pc) if necessary, and the artery ligated nearer the axilla. In difficult cases the operation can be still further facilitated by temporary resection of the clavicle (v. Langenbeck).

LIGATURE OF THE RIGHT AXILLARY ARTERY (Fig. 375).

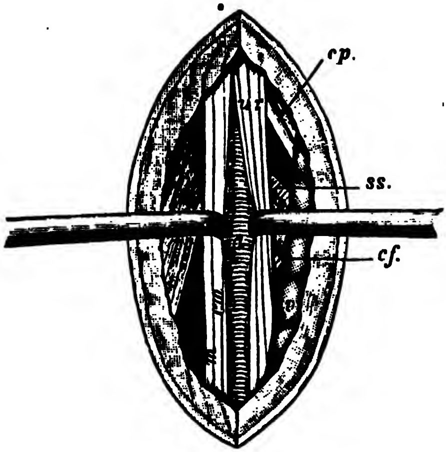
1. **Incision** 2 inches in length, along the **internal border** of the **coraco-brachialis** (the arm in a position of extreme elevation) **beginning** where that muscle crosses the **edge** of the **pectoralis major** at an obtuse angle (Fig. 361, 6).

2. After **division** of the **fascia,** a **bundle of nerves** appears, **surrounding the artery.**

The **axillary vein** (v) lies at the **posterior** margin of the plexus, and **somewhat more superficially.**

3. **Incise the sheath of the bundle of nerves, draw the anterior** cord (**median and middle cutaneous nerves**) **forwards, the post-**

Fig. 375.



erior (ulnar and musculo-spiral nerves) **backwards,** and open the sheath of the artery.

In the middle of the axillary fossa the subscapular (ss) and the posterior circumflex (cf) arteries are given off from the axillary artery posteriorly.

LIGATURE OF THE RIGHT BRACHIAL IN THE MIDDLE OF THE ARM (Fig. 376).

1. **Incision** 2 inches in length, along the **internal** border of the biceps muscle (Fig. 361, 7).

2. Draw the **biceps** (b) **outwards** with blunt hooks. The **median nerve** (m) appears, lying directly upon the artery.

Fig. 376.

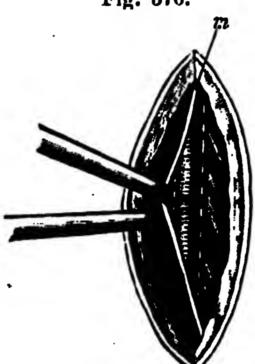
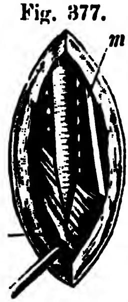


Fig. 377.



3. Isolate the **median nerve** and draw it outwards with a blunt hook and open the sheath of the artery; the latter lies between two veins (brachial veins). (t, triceps muscle).

NB. Sometimes the brachial artery bifurcates into the ulnar and the radial as high up as the upper third of the arm; the radial then generally runs more superficially than the ulnar, and more externally (**upon** the biceps), and the ulnar appears very **small.**

LIGATURE OF THE RIGHT BRACHIAL IN THE FLEXURE OF THE ELBOW (ARTERIA ANCONEA) (Fig. 371).

1. **Incision** a little more than an inch long, $^1/_5$ inch **internal** to the inner edge of the tendon of the biceps (Fig. 361, 8). Be careful to avoid injury to the **median basilic vein** (v). Draw the latter **downwards.**

2. **Divide** the **bicipital aponeurosis** (a). The artery lies directly beneath it, upon the brachialis anticus, between two veins.

The **median nerve** (m) lies a little more **internally** and passes under the pronator teres muscle.

LIGATURE OF THE RIGHT RADIAL IN THE UPPER THIRD OF THE FOREARM. (Fig. 378).

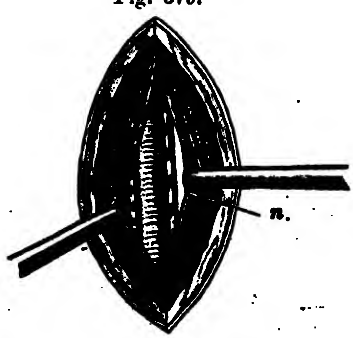
1. **Incision** beginning $1^1/_4$ inch below the flexure of the elbow, extending $1^1/_2$ inch in length upon a line which divides the **radial** from the **middle third** of the **anterior surface** of the supinated forearm (Fig. 361, 9).

2. After **division** of the **fascia,** look for the **interval between the bellies of the supinator longus** (s) and the **flexor carpi radialis** (f), and **open** it with the point of the forefinger.

3. At the bottom lies the **artery,** accompanied by two veins; at its radial side, the **radial nerve** (r).

Fig. 378.

Fig. 379.



LIGATURE OF THE RIGHT ULNAR ARTERY IN THE UPPER THIRD OF THE FOREARM (Fig. 379).

1. **Incision** beginning $1^1/_4$ inch below the flexure of the elbow, extending for a length of $1^1/_2$ inch, along a line which separates the **ulnar** from the **middle third** of the **anterior surface** of the supinated forearm (Fig. 361, 10).

2. After **division** of the **fascia**, look for the **interval between the bellies** of the **flexor carpi ulnaris** (c) and the **flexor digitorum sublimis** (d), and **open** it with the point of the forefinger and with blunt hooks.

2. The **artery** lies at the bottom, accompanied by **two veins**; on its ulnar side lies the **ulnar nerve** (n).

LIGATURE OF THE RIGHT RADIAL ABOVE THE WRIST (Fig. 380).

1. **Incision,** $1^1/_4$ inch in length, along the **radial side** of the **flexor carpi radialis** (Fig. 361, 11)

2. **Divide** the superficial layer of the **fascia** carefully.

3. The **artery**, accompanied by two veins, lies **between** the **flexor carpi radialis** (f) and the **supinator longus** (s).

Fig. 380.

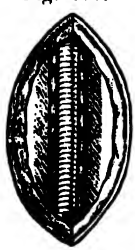
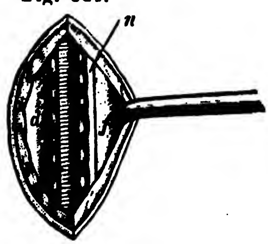


Fig. 381.



LIGATURE OF THE RIGHT ULNAR ARTERY ABOVE THE WRIST (Fig. 381).

1. **Incision** $1^1/_4$ inch in length, along the tendinous **radial border** of the **flexor carpi ulnaris,** which is **attached** to the pisiform bone (Fig. 361, 12).

2. **Divide** the superficial layer of the **fascia** carefully.

3. The **artery,** accompanied by two veins, lies between the tendon of the **flexor carpi ulnaris** (f), and that tendon of the **flexor digitorum sublimis** (d) which lies nearest to the ulna.

On the ulnar side of the artery lies the **palmar** branch of the **ulnar nerve** (n).

LIGATURE OF THE ABDOMINAL AORTA BELOW THE ORIGIN OF THE RENAL ARTERIES (Maas).

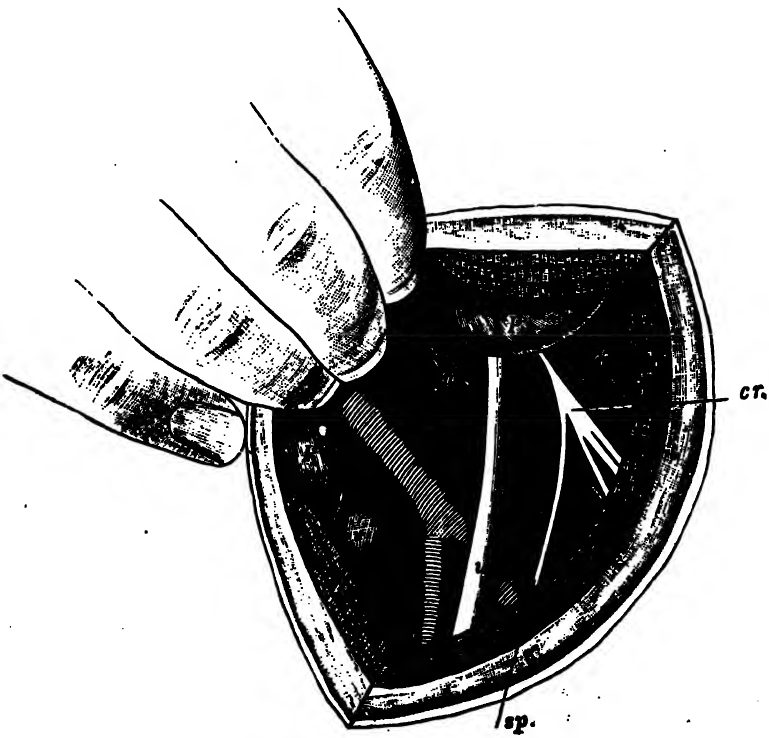
1. **Incision** along the anterior border of the left quadratus lumborum muscle, from the last rib to the crest of the ilium (Fig. 361, 13).

2. After the abdominal muscles and the fascia transversalis have been divided, the wound can be held open with blunt hooks, so that the retro-peritoneal space can be inspected from the lower border of the kidneys downwards, and the aorta can be easily isolated.

LIGATURE OF THE LEFT COMMON ILIAC (Fig. 382).

1. **Incision** 4 to 5 inches long, beginning $1\,^1/_4$ inch below and internal to the anterior superior spine of the ilium, and extending upwards, slightly concave internally, nearly to the last rib (Fig. 361, 14).

Fig. 382.



Ligature of the left common iliac artery.

2. **Divide the layer of fat**, the thin **superficial fascia**, the **muscles — obliquus externus and internus**, and **transversalis**, and the thin **fascia transversalis**, in succession, until the **peritoneum** is exposed.

3. The **peritoneum** (p) is carefully pushed **inwards towards the umbilicus**, and drawn **with the fingers** towards the inner edge of the wound.

4. The **ureter** (u) generally remains attached to the peritoneum; if not, it is seen obliquely crossing the bifurcation of the iliac, in company with the genito-crural nerve (sp) and any injury to it must be carefully avoided.

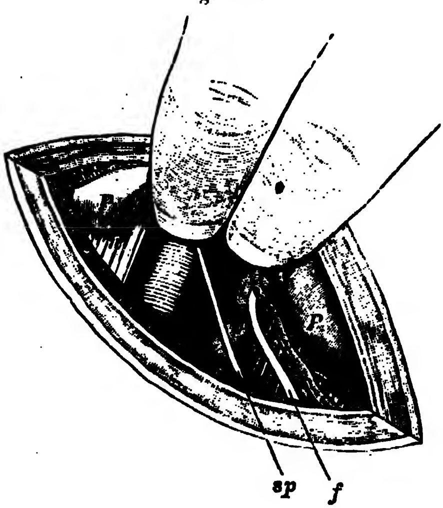
5. The **common iliac artery** now lies exposed in its **entire** length, from the aorta to its bifurcation, along the internal margin of the ilio-psoas (mm): on the left side of the body the iliac vein lies at the inner side of the artery; on the right side of the body, it lies **behind** the artery.

NB. The **internal iliac artery** can also be ligated at this point.

LIGATURE OF THE RIGHT EXTERNAL ILIAC ARTERY (Fig. 383).

1. **Incision**, $^1/_2$ inch above Poupart's ligament, and parallel with it, 3 to 4 inches long, **slightly convex, beginning** $1^1/_4$ inch internal to the anterior superior spine, and **ending** in the neighborhood of the internal inguinal ring — **without** exposing the latter and the spermatic cord (Fig. 361, 15).

Fig. 383.



2. **Divide the layer of fat**, the thin **superficial fascia**, the strong tendinous **aponeurosis** of the **external oblique**, the **muscular fibres** of the **internal oblique**, then the horizontal **muscular fibres** of the **transversalis** in the outer angle of the wound.

3. Divide the subjacent thin **fascia transversalis** carefully. (In fat subjects, another thin layer of fat is met.)

4. Press the **peritoneum** (p) carefully **towards the umbilicus** with the hooked fingers (NB. Without separating the **fascia iliaca**, together with the large vessels, from the wall of the pelvis).

5. The **artery** lies at the **internal border** of the ilio-psoas; the vein (v) on its **inner side**; the anterior crural nerve (n), covered by the iliac fascia, on the **outer side**; the genito-crural **nerve** (sp) passes obliquely across the artery.

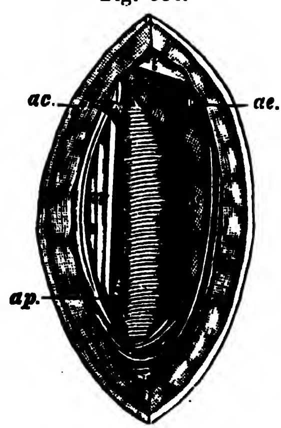
LIGATURE OF THE RIGHT FEMORAL BELOW POUPART'S LIGAMENT (Fig. 384).

1. **Incision**, beginning **halfway between the anterior superior spine** and the **symphysis**, $^1/_{10}$ inch above Poupart's ligament, and extending 2 inches downwards (Fig. 361, 16).

2. **Divide** the **superficial fascia**.

3. **Divide** the **fat**, and dispose of the **lymphatic glands** by drawing them aside, or by extirpation.

Fig. 384.



4. **Divide the fascia lata.**

5. **Open the sheath of the vessels**, $^1/_2$ inch **below Poupart's ligament** (l), **because immediately** below the ligament is the **origin of the circumflex iliac** (ac), and the **epigastric artery** (ae).

6. The **femoral vein** (v) lies **internal**, the **anterior crural nerve** (n) **external** to the **artery.**

LIGATURE OF THE RIGHT FEMORAL BELOW THE ORIGIN OF THE PROFUNDA (p). (AT THE LOWER ANGLE OF SCARPA'S TRIANGLE — Fig. 385).

1. **Incision** 2 inches in length, along the internal border of the sartorius, beginning the breadth of six fingers (3 to 4 inches) below Poupart's ligament (Fig. 361, 17).
2. **Expose** the **border** of the **sartorius muscle** (s), and draw it **outwards.**
3. **Open** the **sheath** of the **vessels.** The **femoral vein** (v), lies on the **inner** side of the artery, and somewhat **behind** it; the **long saphenous nerve** (n) on the **outer** side.

Fig. 385.

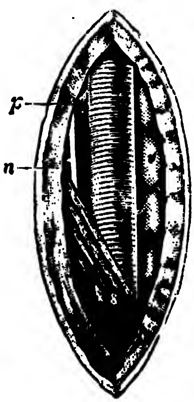
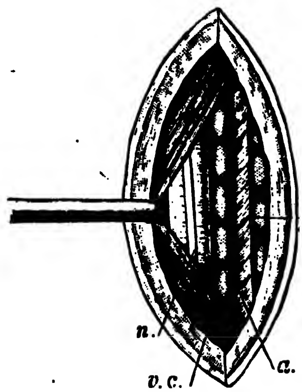


Fig. 386.



LIGATURE OF THE RIGHT FEMORAL IN THE MIDDLE OF THE THIGH (BEHIND THE SARTORIUS) (Fig. 386).

1. **Incision,** 3 to 4 inches long, **down to the sartorius,** in the **middle** of an imaginary line drawn **from the anterior superior spine to the internal condyle of the femur** (Fig. 361, 18).
2. **Open the sheath of the sartorius, isolate the muscle** (s), **and** draw it **outwards,** until the **posterior wall of the sheath of the muscle,** which covers the vessels, appears.
3. After opening the sheath, expose the **artery. Upon** the **artery** lies the **long saphenous nerve** (n), **behind** the artery, the **femoral vein** (vc). The saphenous vein (vs) lies more superficially and internally.

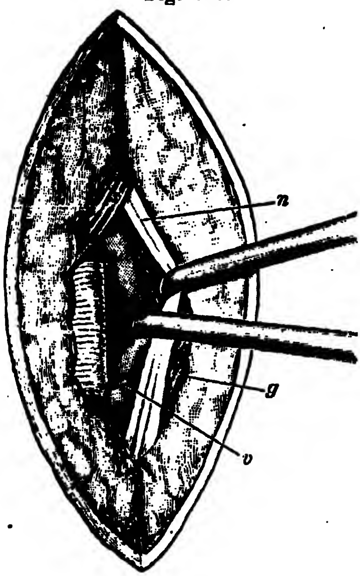
LIGATURE OF THE RIGHT POPLITEAL ARTERY (Fig. 387).

1. **Incision,** 3 inches long, at the **outer edge** of the semimembranosus, extending downwards across the whole popliteal space (Fig. 361, 19).

2. **Divide** the **thick layer of fat,** until the **internal popliteal nerve** comes in sight.

3. The **internal popliteal nerve** (n) must be drawn to the **outer side; behind** and **somewhat internally** lies the **popliteal vein** (v), which must be isolated and drawn **a little to the outer side; behind** the vein, and **somewhat internally,** lies the **artery.**

Fig. 387.



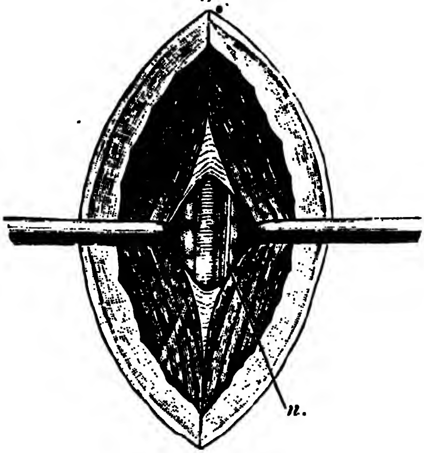
LIGATURE OF THE LEFT ANTERIOR TIBIAL ARTERY ABOVE THE MIDDLE OF THE LEG (Fig. 388).

1. **Incision,** $2^1/_2$ to $3^1/_2$ inches long. $1^1/_4$ inch external to the crest of the tibia (halfway between tibia and fibula) (Fig. 361, 20).

2. **Divide** the **fascia,** following a white tendinous line which indicates the interval between the **tibialis anticus muscle** (ta) and the **extensor proprius pollicis** (eh); **open** the intermuscular **space** with the **point** of the **index-finger** until the deep fascia is seen.

3. After careful **division** of the **deep fascia,** the artery comes in sight between two veins; on its **outer side** lies the **anterior tibial nerve** (n).

Fig. 388.

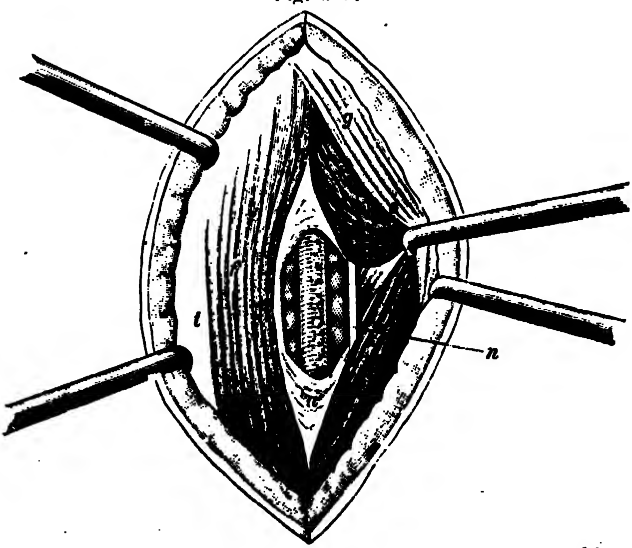


LIGATURE OF THE RIGHT POSTERIOR TIBIAL ARTERY ABOVE THE MIDDLE OF THE LEG (Fig. 389).

1. **Incision** 3 to 4 inches long, $^1/_2$ inch internal to the inner border of the tibia (Fig. 361, 21).

2. After **division** of the **fascia**, draw the edge of the **gastrocnemius** (g) **backwards**, separate the **soleus** from the **flexor digit-**

Fig. 389.



orum longus, and open the interval between these muscles with the point of the finger, until the strong **deep aponeurosis** appears, which consists of fibres of the tendon of the soleus and the fascia of the leg.

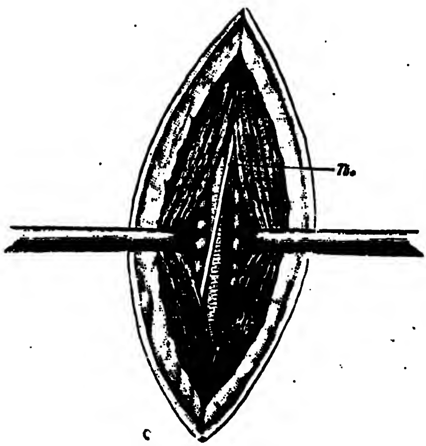
3. After **division** of this **aponeurosis**, the **artery** appears between its two veins; somewhat more posteriorly lies the **posterior tibial nerve** (n).

LIGATURE OF THE LEFT ANTERIOR TIBIAL ARTERY IN THE LOWER THIRD OF THE LEG (Fig. 390).

1. **Incision** 2 to $2\frac{1}{2}$ inches long, vertical, a finger's breadth external to the crest of the tibia (Fig. 361, 22).

2. **Divide** the **fascia.** Force the fore-finger into the interval **between** the **tibialis anticus muscle** (t.a) and the **extensor proprius pollicis** (eh), and by tearing up and down, separate the bellies of the muscles down to the interosseous membrane (about 1 inch deep).

Fig. 390.



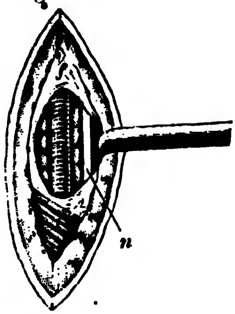
3. The **artery** lies upon the membrane between two veins, accompanied in front and internally by the **anterior tibial nerve** (n).

LIGATURE OF THE RIGHT POSTERIOR TIBIAL BEHIND THE INTERNAL MALLEOLUS (Fig. 391).

1. **Incision** $1\frac{1}{4}$ to $1\frac{3}{4}$ inch long, **halfway** between the **internal malleolus** and the **tendo Achillis** (Fig. 361, 23).

2. **Divide** the **fascia** (f) [strengthened by fibres of the **annular ligament** (l)].

Fig. 391.



3. Directly **beneath** this lies the **artery**, between two veins; the **posterior tibial nerve** (n) lying **behind** it.

NB. The **tendon-sheaths** of the **tibialis posticus**, the **flexor longus digitorum**, and the **flexor pollicis longus** must not be opened.

BLEEDING (VENESECTION, PHLEBOTOMY).

1. The most prominent vein under the skin in the flexure of the elbow is generally opened for bleeding, and also for transfusion.

2. This is usually the **median basilic vein.** But as this vein generally crosses the brachial artery, and is only separated from it by the thin bicipital aponeurosis, it is advisable to feel the pulsation of the artery before the operation, and to open the vein either above or below the point where they cross.

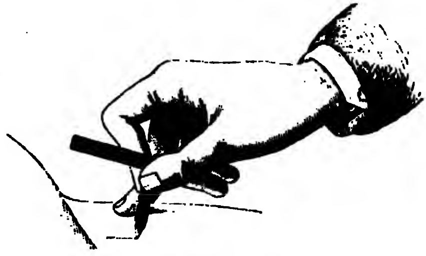
3. Let the patient **lie down,** and the arm hang, so as to fill the veins.

4. Tie a bandage (or a folded handkerchief) around the middle of the arm, firmly enough to stop the return of venous blood, but not so tight as to cut off the arterial supply — the radial pulse should not be made to disappear. The knot of the bandage must be made so that it can be untied by pulling on one end.

5. The operator steadies the arm by wedging his hand between the patient's arm and chest; and the vein, by pressing his thumb upon it below the point to be punctured.

6. A puncture is made through the skin into the vein with a lancet (Fig. 392), or still

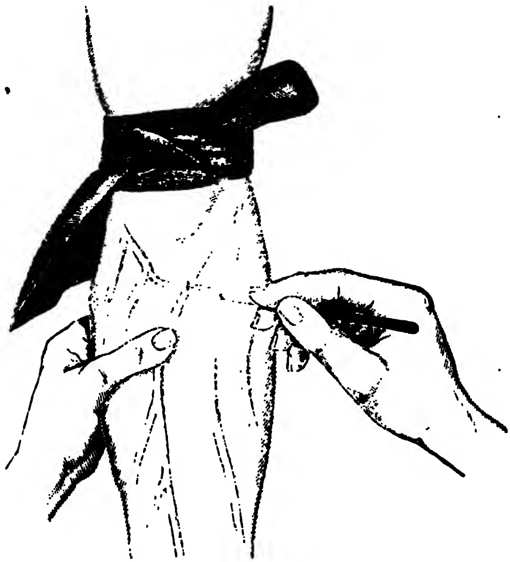
Fig. 392.



Venesection with the lancet.

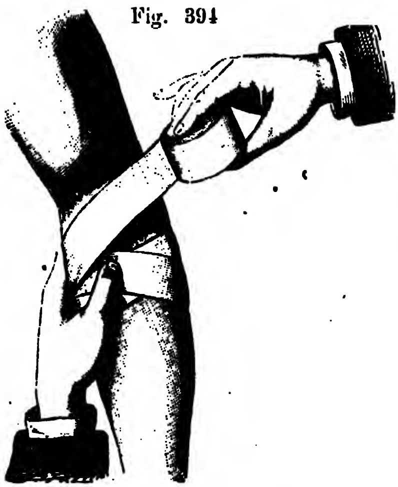
better with the phlebotome of Lorins (Fig. 393), and the opening is enlarged by raising the point so that the anterior wall of the vein is opened **obliquely** for about $^1/_5$ inch.

Fig. 393.



Venesection with the phlebotome.

Fig. 394



Dressing after venesection.

7. The blood should spout out in a strong stream; if it does not, the flow can be increased by the alternate opening and closing of the hand.

8. When a sufficient quantity has been allowed to escape, remove the constricting bandage, push the wound in the skin somewhat to one side of the vein, lay a small antiseptic compress upon it, and secure the latter with a figure-of-eight bandage, the forearm being slightly flexed (Fig. 394).

TRANSFUSION.

After a sudden and severe loss of blood, caused by injury of some of the large vessels, the arterial blood-pressure sinks so low that the heart is no longer able to keep the contents of the blood-vessels in motion. It labors without effect, like an empty pump, and **death by hemorrhage** follows, even while there is still a sufficient quantity of red blood corpuscles in the vessels to support life.

Direct transfusion of blood from the artery of a healthy person into the vein of another dying of hemorrhage, would fill the vessels of the latter again, and preserve his life. But unfortunately it is impossible to avoid with certainty the formation of clots in the conducting canula, and these might cause dangerous obstruction of the vessels in the person receiving the blood. It is also seldom possible to find perfectly healthy persons, who are ready to furnish blood in this way, to save the life of another.

Direct transfusion of the blood of an animal into the veins of a man, is to be rejected, because a poison is produced by the mixture of different kinds of blood, which quickly dissolves white and red corpuscles, and not only causes coagulation of the blood, but may also result in hemaglobinaemia, generally fatal, and hemaglobinuria.

According to recent experiments (Köhler, etc.) **transfusion of defibrinated blood,** even human blood, is just as dangerous, because by beating the blood to extract the fibrin, fibrin-ferment is set free, which causes coagulation of the circulating blood, and dissolves the corpuscles (ferment poisoning, Köhler). Hence, according to our present opinions, **every form of transfusion of blood is to be rejected.**

On the other hand, **injection of a solution of common table salt** (7 parts to 1000) into the veins, suffices to raise the blood pressure within the vessels, so that the heart can again set the column of blood in motion, and carry the materials of nutrition to the various organs of the body (Kronecker).

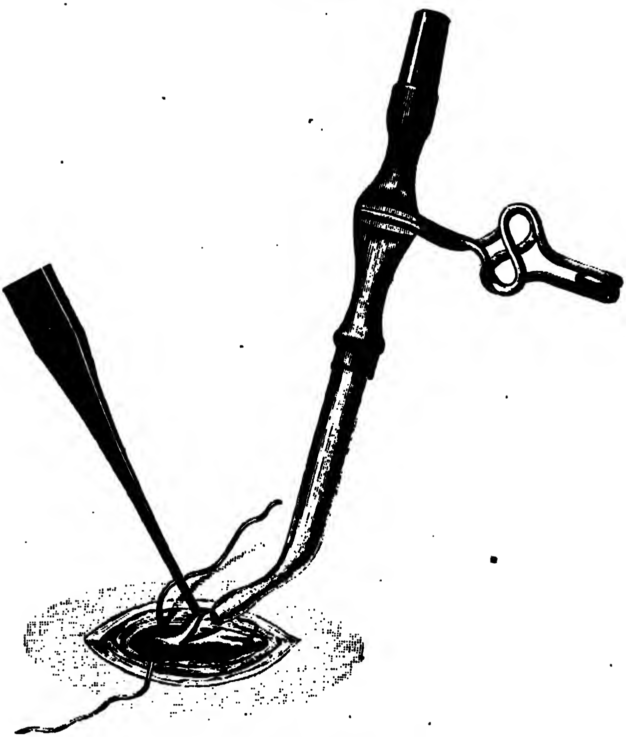
To perform this operation upon a patient, a subcutaneous **vein** (for instance, the median basilic in the flexure of the elbow, or the great saphenous vein in front of the internal malleolus) must be **exposed,** by cutting a flap in the skin, and isolated, so that **two catgut strands** can be drawn under it.

The peripheral end of the vein is **ligatured** with **one** of the strands of catgut, the other is placed under the central end.

The exposed vein is **opened** by raising the upper wall with a small toothed forceps, and making an oblique cut underneath with the scissors, so as to form a small flap.

This wound is held open by lifting the flap, and a **canula** (of glass, hard rubber, or silver) rounded at the point, is introduced into the central end, and secured by the second catgut thread (Fig. 395).

Fig. 395.



Introduction of the canula.

The canula and a rubber tube attached to it, which has a female tip of hard rubber at the other end, are completely filled beforehand with salt solution, and closed by a spring clamp.

A glass irrigator (see Fig. 12) is employed for making the injection of the salt solution, or a graduated glass cylinder (Fig. 396), which contains 10 to 15 fluid ounces, and ends below in a knob-like perforated end, to which is attached a rubber tube 16 inches long. In the lower end of the latter is a small nozzle of hard rubber or glass, which exactly fits into the rubber female tip attached to the canula.

After the vessel has been very carefully cleaned and disinfected, it is filled with a solution of pure table salt, 7 parts in 1000 of distilled water, warmed to a temperature of 104° F. The nozzle of the tube is depressed until the water jets from it, and the point is firmly inserted into the rubber tip attached to the canula, already filled with the solution.

After all the air-bubbles have been removed from the tube by pressing and stroking it upwards, the glass cylinder is raised with one

hand and the clamp is loosened with the other, so that the column of water in the cylinder sinks very slowly — at the fastest, 3 fluid drachms in a second.

The clamp can also be entirely removed, and the rapidity of the flow regulated by elevating and depressing the glass cylinder.

To prevent the fluid from cooling during the operation, the hand which holds the cylinder can also hold around it a rubber bag filled with hot water (Fig. 396).

As soon as the cylinder is almost empty, the tube is closed by pressure between the fingers, and disconnected from the canula.

The canula is then withdrawn from the vein, the central end of the latter ligated, the wound carefully cleansed and disinfected, and an antiseptic dressing applied.

Fig. 396.

Graduated glass cylinder.

A **syringe** is less suitable for use in transfusion, (1) because the pressure is liable to be too strong, (2) because the piston is apt to infect the blood — by rancid oil, dried fluid from previous use, etc., and (3) because its use increases the danger of air finding admittance to the vein.

Before proceeding to transfusion, an attempt should be made to raise the low blood-pressure by bandaging one or several extremities of the patient, and thus forcing the blood which remains in them into the rest of the vascular system (**auto-transfusion** — P. Müller) (Fig. 397), so that the heart can again do efficient work.

Fig. 397.

Auto-transfusion.

Sometimes this proceeding will make it possible to dispense with transfusion; sometimes the failing vitality can be thus maintained — at least, until transfusion can be performed.

THE REMOVAL OF LIMBS.

(AMPUTATIONS AND DISARTICULATIONS.)

GENERAL RULES FOR AMPUTATIONS.

PREPARATION.

1. Every **assistant** must have his particular duty and position assigned to him. The **patient** must be so placed that he can be **easily** chloroformed, and that the operator and his assistants may have **sufficient** room for their work.

2. The **cut surfaces** of the limb to be amputated must be **turned** directly towards the light.

3. The **operator** is most advantageously placed when the **amputated** limb will fall at his **right** side.

4. Before the operation is begun, the skin in the neighborhood of the place of amputation must be **shaved**, very carefully **cleansed**, and then thoroughly **disinfected** as has been described on page 7.

5. When anaesthesia has been produced, the extremity is **made bloodless** far above the place of amputation, and again **washed with** carbolic solution when the bandage has been removed.

6. During the entire operation, all the rules of **antisepsis are to be most strictly observed.**

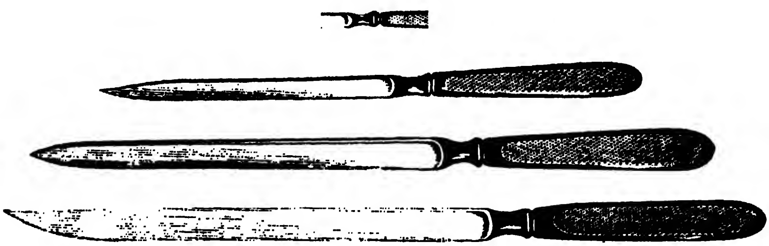
DIVISION OF THE SOFT PARTS.

The **soft parts** are to be divided so that they will form an **abundant covering** for the sawn end of the bone. The muscles are best cut through **perpendicular** to the long axis of the limb, and the knife must not be made to act by pressure, but should be drawn back and forth as in carving a joint of meat. If the muscles are cut obliquely, the vessels will also be obliquely divided, and it is then not so easy to ligate them securely. For this reason, the methods most to be recommended are the **circular method,** and the methods by **skin-flaps** with **circular division** of the **muscles.**

1. CIRCULAR METHOD OF CELSUS.

All the soft parts are divided down to the bone (Fig. 399) with a knife (Fig. 398), the length of which is proportioned to the thickness of the limb, **with one stroke,** and the bone **immediately** sawed through. But in order to allow the soft parts to be united over the

Fig. 398.



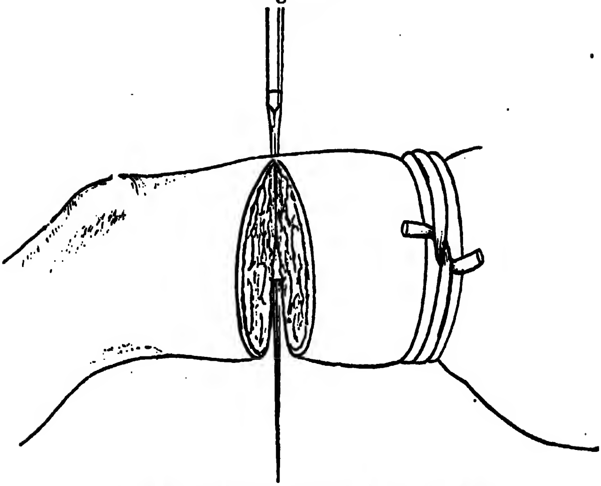
Amputation knives.

bone without tension, the bone must be **again** sawed off at a distance above the first place equal to half the diameter of the limb. To accomplish this, the end of the bone is seized with lion-toothed forceps, and the periosteum detached upwards with a raspatory until the necessary amount of bone has been exposed (Fig. 400).

Of all the methods, this one, in limbs with **one bone,** gives the smallest and smoothest surface to the wound [1]); but it is not suitable for limbs with a great amount of muscle, although very well adapted to patients who are emaciated and exhausted by long continued suppuration.

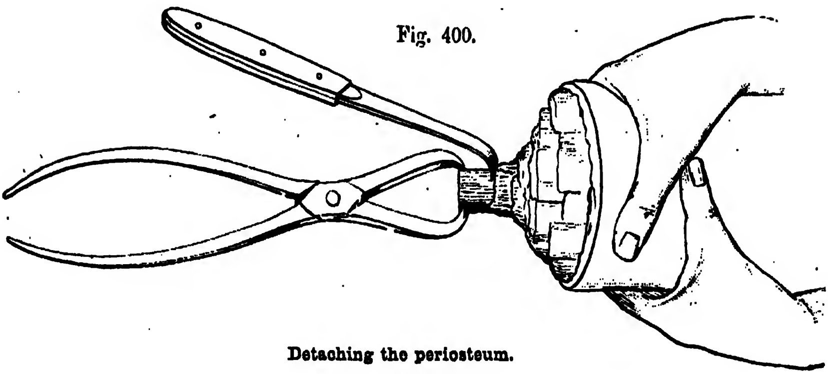
[1]) This method was recommended by Brünninghausen, as far back as his time, in his „Erfahrungen und Bemerkungen über die Amputation", Bamberg, 1818, page 65, and page 76.

Fig. 399.



Amputation by the circular method of Celsus.

Fig. 400.



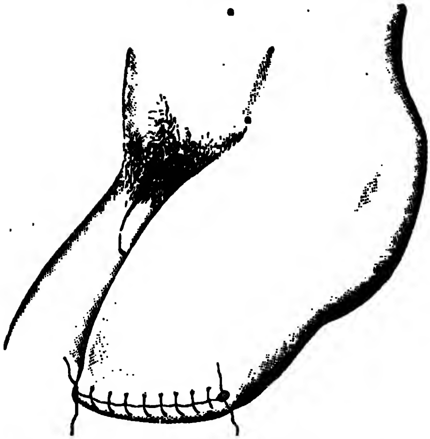
Detaching the periosteum.

The wound can be united by sutures passed in any direction. Fig. 401 shows the appearance of the freshly formed stump closed transversely, and Fig. 424 the same closed vertically.

2. METHOD BY CIRCULAR SKIN-FLAP (Petit).

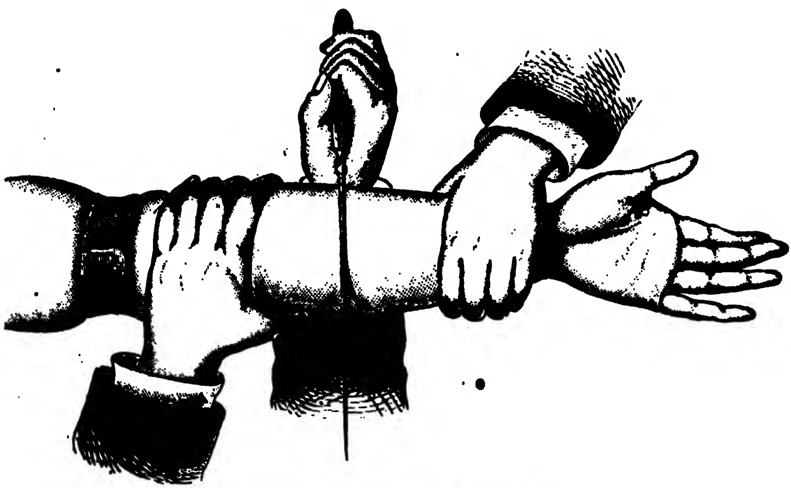
The skin is first divided down to the fascia by an incision encircling the limb (Fig. 402). Then, while an assistant strongly retracts the skin, it is dissected up by repeated circular strokes down to the fascia, the knife being held perpendicular to the axis of the limb

Fig. 401.



Stump after amputation by the circular method of Celsus.

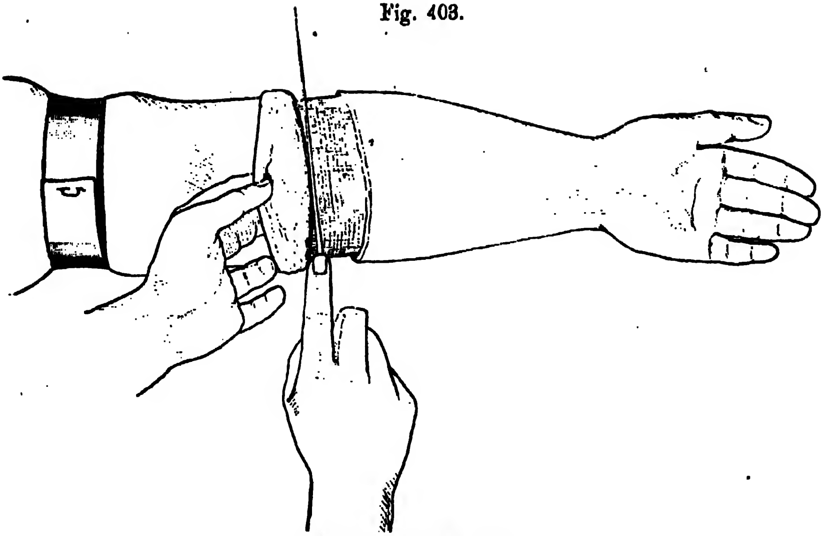
Fig. 402.



Amputation by circular skin-flap.

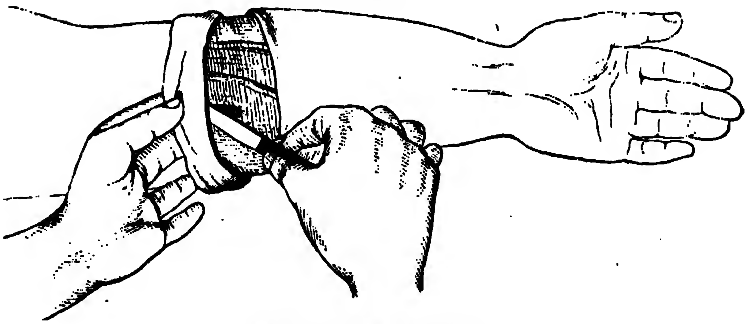
(Fig. 403) (not as in Fig. 404), so that the skin can be turned up like a cuff. The length of the cuff-flap must equal half the diameter of the limb. If the cut edge of the skin is too narrow, because the circumference of the limb quickly increases above the site of the incision, the skin may be divided by one or two short longitudinal incisions at opposite points (see Fig. 520). Close to the place where

Fig. 403.



Forming the skin-flap.

Fig. 404.



Wrong use of the knife.

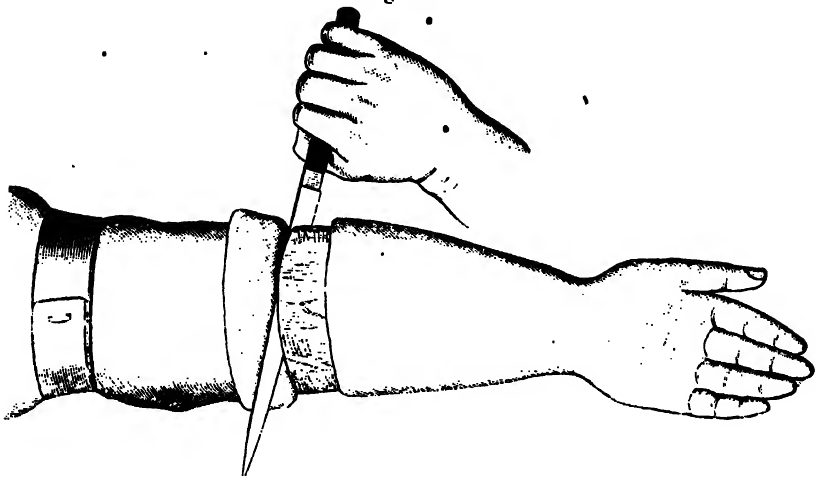
the flap is folded back, all the muscles are cut through to the bone with a bold circular sweep (Fig. 405), and the bone then sawed through. Fig. 406 shows the appearance of the freshly made stump.

3. METHOD BY FLAPS OF SKIN WITH CIRCULAR DIVISION OF MUSCLES (Lowdham, 1679)[1].

Two semicircular flaps of skin are cut with a large scalpel having a convex blade (Fig. 407), isolated from the fascia up to their

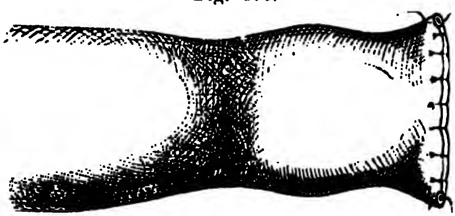
[1]) See Uhde, v. Langenbeck's Archiv für Chirurgie, Bd. 27, p. 485.

Fig. 405.



Division of the muscles at the folded edge of the skin-flap.

Fig. 406.



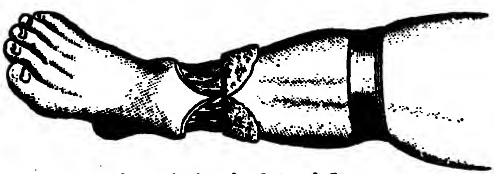
Stump after amputation by the circular skin-flap method.

Fig. 407.

Langenbeck's amputation knife.

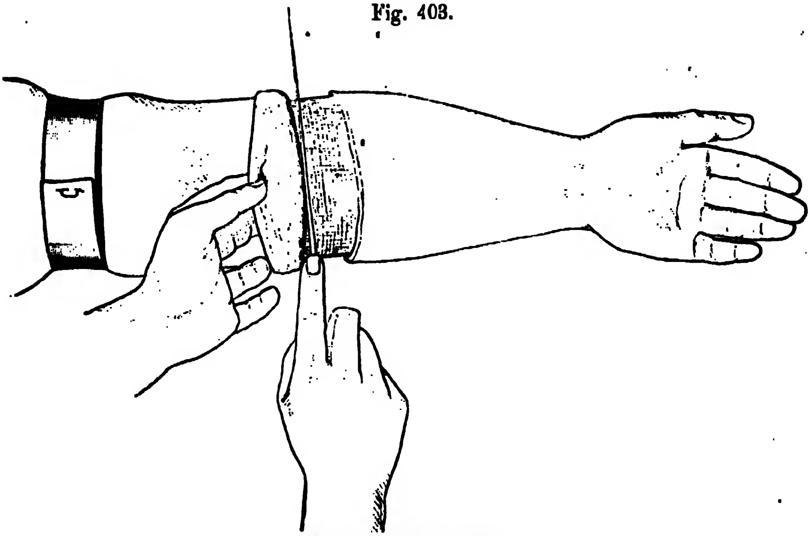
bases, and turned back (Fig. 408). It is generally best to form a **large anterior** and a smaller posterior flap (Fig. 409), so that the larger flap hangs down like a curtain over the divided muscles. The

Fig. 408.



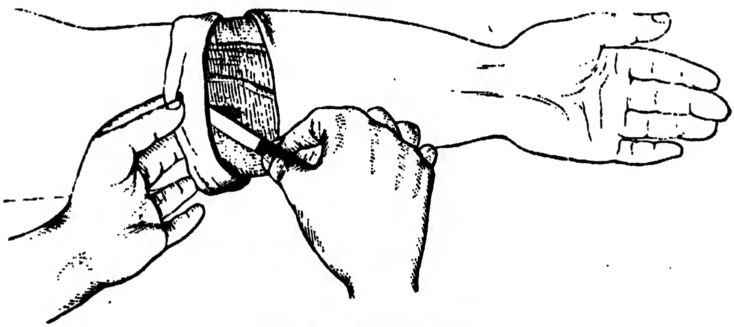
Amputation by lateral flaps.

Fig. 403.



Forming the skin-flap.

Fig. 404.



Wrong use of the knife.

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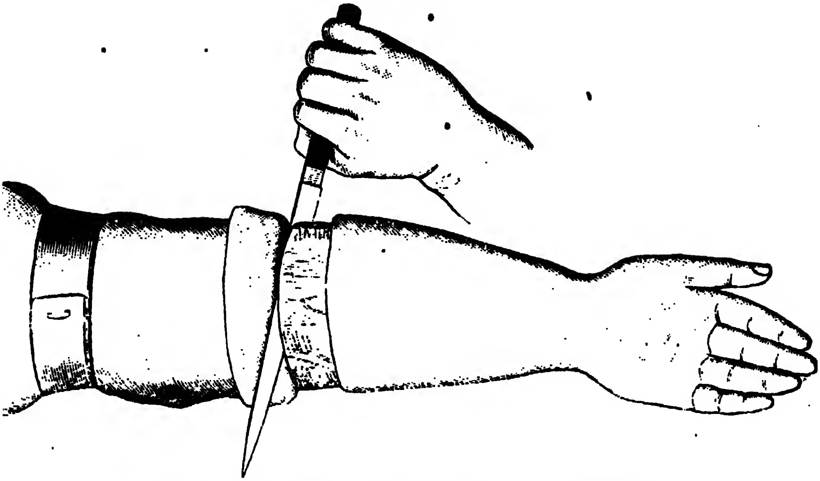
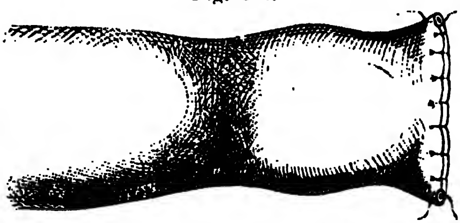


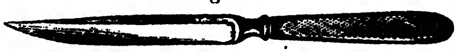
Division of the muscles at the folded edge of the skin-flap.

Fig. 406.



Stump after amputation by the circular skin-flap method.

Fig. 407.



Langenbeck's amputation knife.

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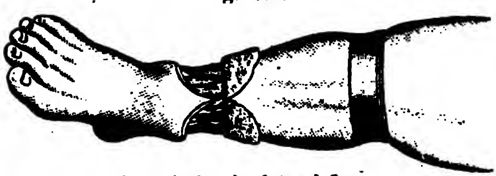
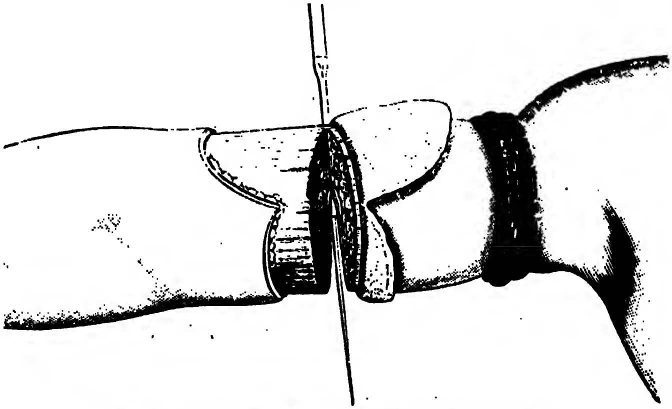
Fig. 408.



Amputation by lateral flaps.

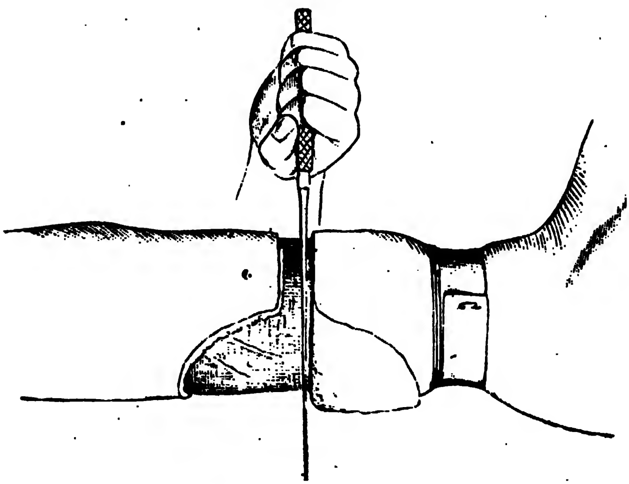
skin can also be divided posteriorly by a circular incision, and then dissected somewhat upwards by a few vertical cuts (Fig. 410). In this case the base of the large anterior flap must be a little **less than half** the circumference of the limb, and the length must equal the diameter of the limb.

Fig. 409.



Large anterior and small posterior flaps of skin.

Fig. 410.



Anterior skin flap with posterior circular incision.[1]

[1]) After Liston: Practical Surgery. 3. Ed. 1840. page 378.

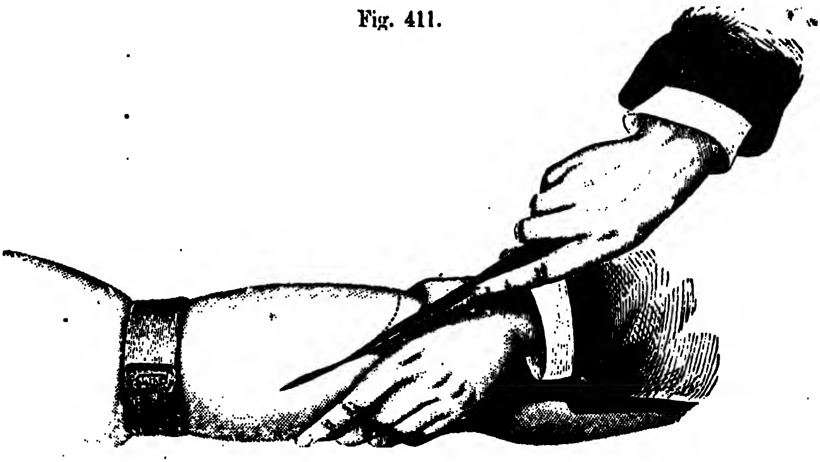
All the muscles are divided down to the bone, by a circular cut (Fig. 409), close to the point where the skin-flaps are turned back (Fig. 409), and the bone is then sawed off.

4. METHOD BY MUSCULAR FLAPS.

The methods in which the flaps are formed of **skin and muscle** are generally less to be recommended, because they make larger surfaces in the wound, and especially because the arteries are divided obliquely.

The flaps can be cut either **from without inwards** (Langenbeck) (Fig. 411), for which very sharp knives are needed; or **from within**

Fig. 411.



Method by muscular flaps. Forming the flap, according to Langenbeck.

outwards (Verduin), by transfixing the soft parts at the base of the flap, close to the bone, with a long double-edged knife, and cutting out obliquely towards the surface with long sawing strokes (see disarticulation at the hip, Fig. 531, page 279).

The latter method is inferior in amputations for gunshot fractures, because the knife is apt to catch upon projectiles or splinters of bone. The double-edged knife has the disadvantage that by uncertain handling it may wound the vessels in the flap in several places. The double-edged knife is also much more difficult to sharpen than a knife with one edge, and flaps can be cut from within outwards just as well with the latter, especially when the point is shaped like that of the largest knife in Fig. 398.

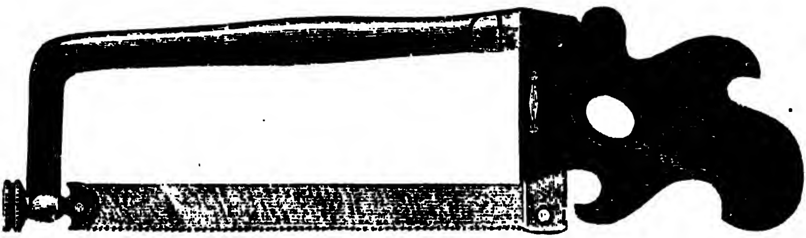
A modification of the method by muscular flaps is the **oval flap** (**Langenbeck**) in which two flaps run together in a transverse incision

posteriorly, so that the wound acquires the shape of the heart on playing cards. It is especially fitted for the disarticulation of small joints (see the disarticulation of the fingers and toes). For the larger limbs it has no advantage over the other methods, except its rapidity of execution — which is now seldom of importance, since the introduction of chloroform and of the bloodless method. Great practice, and very sharp knives, which are not to be had in war, are essential to its perfect performance.

SAWING THE BONE.

After division of all the soft parts, the operator exchanges the knife for an amputation saw (Figs. 412 and 413), applies the edge

Fig. 412.



Butcher's saw.

Fig. 413.

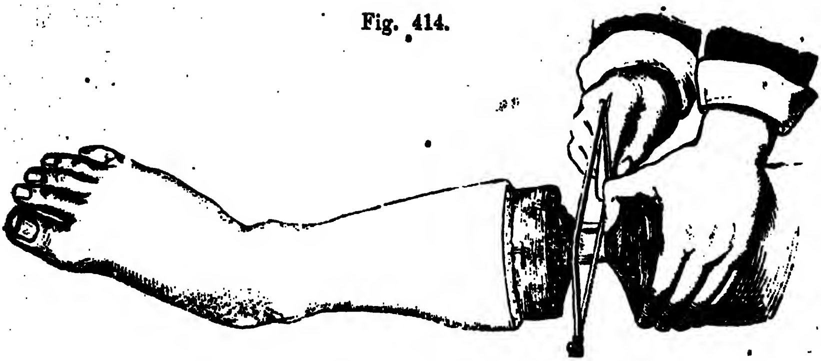
Amputation saw.

of his left thumb-nail to the bone, to steady the saw (Fig. 414), and with long even strokes, without pressure, he saws through the bone with moderate rapidity.

During the use of the saw, the soft parts are strongly retracted by one assistant, with his hands or with a retractor of cloth (Figs. 415 and 416) washed in carbolized water; while another assistant holds the lower part of the limb firmly, depressing it a little towards the end of the sawing, so that the saw shall not become wedged in the cut in the bone (Fig. 417).

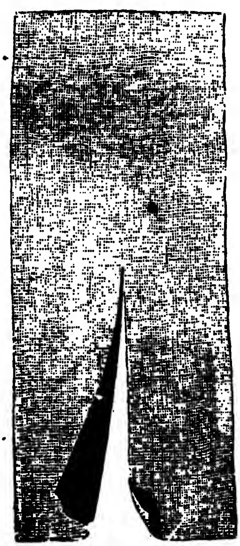
In limbs with two bones, before sawing the latter, the intervening soft parts must be completely divided, by inserting a narrow

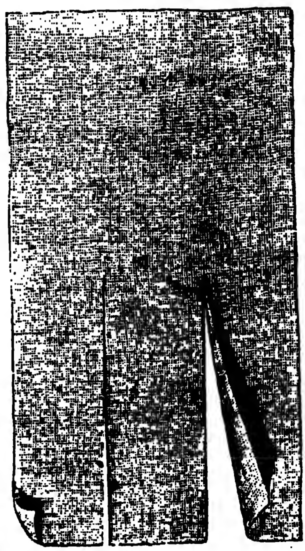
Fig. 414.



Sawing the bone.

Fig. 415. Fig. 416.





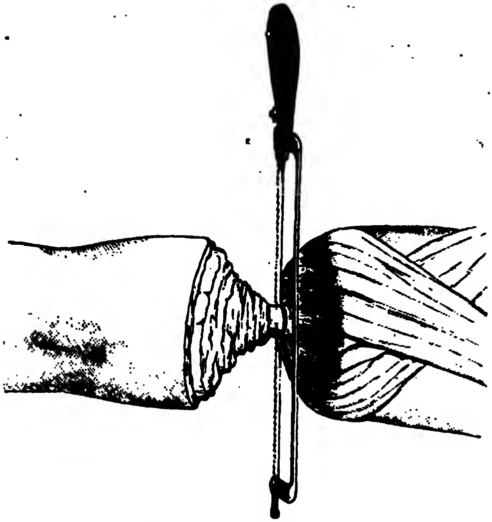
Retractors.

For one bone. For two bones.

double-edged knife (see Fig. 398 above) between the bones, first on one side and then on the other, and bringing its edge to bear on each bone in turn, as is indicated in Fig. 418.

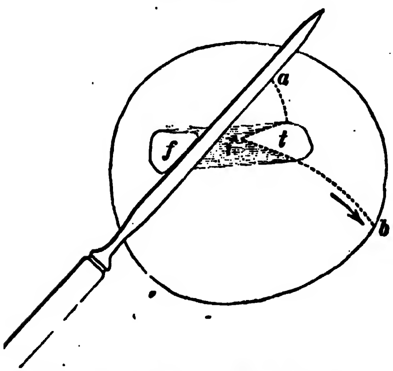
Then the soft parts are drawn back with a retractor made of a compress split in three tails, the middle one being passed between the bones with the dressing-forceps (Fig. 419) and both bones are sawed at the same time.

Fig. 417.



Retracting the soft parts.

Fig. 418.

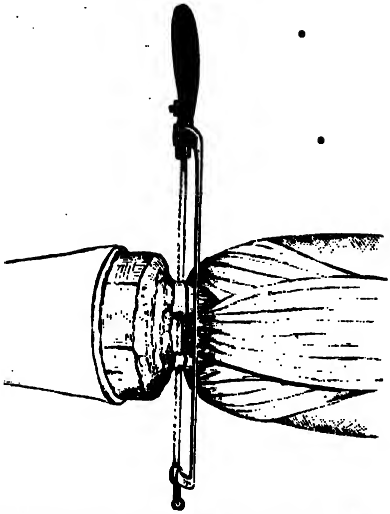


Manner of using the interosseous knife.
f = fibula; *t* = tibia; *i* = interosseous space.

After the bones have been sawed off, any points which happen to project are snipped off with the bone cutting forceps (Fig. 420), and sharp corners are removed with a small saw (Fig. 421) or rounded with a file.

Then all divided vessels, arteries and veins, which can be recognized as such, are ligated as is represented on pages 12—14. The

Fig. 419.

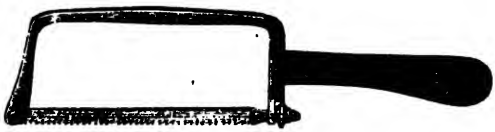


Use of the saw in a limb with two bones.

Fig. 420.

Bone cutting forceps.

Fig. 421.



Small saw.

position of the vessels may be recalled to memory before the operation, if necessary, with the aid of diagrams of transverse sections of the limb. It is also advisable to draw out the stumps of the nerve trunks which project into the wound with forceps, and to cut them off with the scissors, as this will diminish or prevent the pain in the wound or in the cicatrix.

If the surgeon has had sufficient practice in the ligation of the vessels, the wound may then be closed, and the constricting band left in place until the dressing has been applied. But if he does not dare to leave it, for fear of secondary hemorrhage, he should proceed as has been described on page 184.

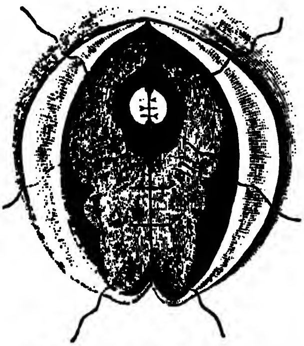
CLOSURE OF THE WOUND.

The wound must be closed in such a way that blood and serum can not collect in it, but will pass at once to the surface, where they

can be immediately and readily absorbed by the antiseptic compressive dressing.

More useful than any thing else for accomplishing this purpose, are the **deep and sunken sutures** which have been explained on page 20, and also the use of drainage tubes (page 20), of drainage openings (page 23), and the method of leaving the incision open at the most dependent part for drainage.

Fig. 422.



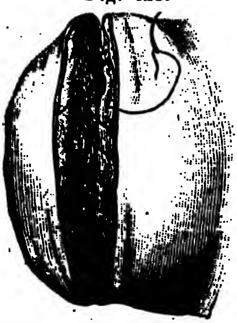
Deep periosteal and muscular sutures.

The accompanying illustrations show the application of the sutures after an amputation of the thigh by the circular method.

The periosteum which has been retracted is brought forward, and united over the sawn surface of the bone by some catgut sutures (Fig. 422).

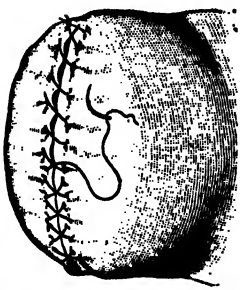
First the deeper (Fig. 422), and then the more superficial layers (Fig. 423) of the muscular tissues are sewed together with long slightly curved needles and thick catgut; and finally the cut edges of the skin are brought into exact apposition by a double continued suture (Fig. 424), but the lowest angle of the wound is left open a little, or else a couple of button-hole openings are made in the skin at each side, as has been described on page 23 and represented in Fig. 41. Figs. 39 and 40 show the mode of action of the deep sutures. If this method is employed, the insertion of drainage tubes is unnecessary.

Fig. 423.



Sunken muscular sutures.

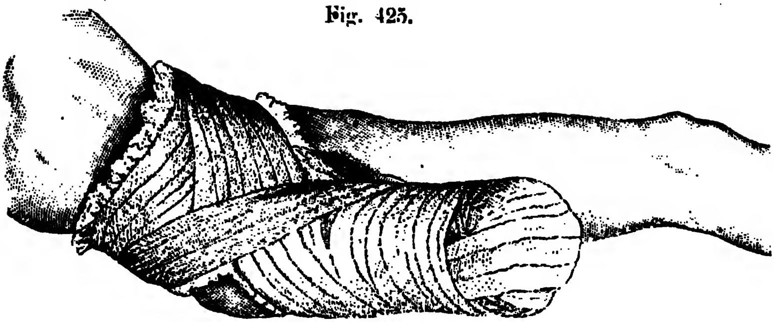
Fig. 424.



Suture of the skin.

If the antiseptic permanent dressing, as has been described on page 26, and as is represented in Fig. 425, is applied, and the constricting band not removed until then, the dressing can generally remain for several weeks, until union by first intention is complete, and then all the blood which the patient has lost in consequence of the amputation, is found in the form of a small odorless crust on the inner surface of the dressing.

Fig. 425.



Antiseptic cushion dressing after amputation of the thigh.

GENERAL RULES FOR DISARTICULATIONS.

1. The operator generally stands so as to face the patient, and holds the limb to be removed in his left hand.

2. For division of the soft parts the circular method is less suitable than the flap method. As there are generally large surfaces of bone to be covered in these cases, proportionally large flaps must be formed, either of skin alone, or of skin and the under-lying muscle.

3. In some cases a large anterior and a small posterior flap is best (knee, shoulder, hip); in some cases the posterior flap must be the the larger (ankle, metatarsal joints).

4. For the smaller joints (fingers, toes), the oval method is peculiarly well suited.

5. After division of the soft parts covering the joint, the latter is opened by putting the exposed ligaments strongly on the stretch by proper movements of the limb, and then dividing them with the knife.

6. The separation is completed by the division of the remaining ligaments, and of the capsule of the articulation, and finally a piece may be sawed off from the joint surface which is left. In other respects the method of procedure is the same as in amputations.

AMPUTATIONS AND DISARTICULATIONS OF THE UPPER EXTREMITY.

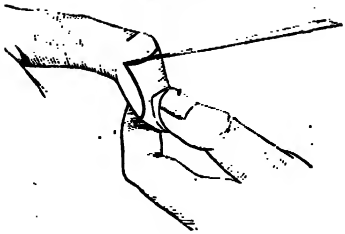
a. DISARTICULATION OF THE THIRD PHALANX OF THE FINGER.

(With the formation of a palmar flap from without inwards.)

1. The hand is held in pronation opposite the operator, who seizes the end of the finger, and flexes the third phalanx.

2. A slightly curved incision is carried transversely across the head of the second phalanx $^{1}/_{10}$ inch below the articular surface, and opens the joint capsule (Fig. 426).

Fig. 426.



3. The point of the knife divides both lateral ligaments. The blade is inserted behind the palmar surface of the third phalanx, the edge being directed downwards (Fig. 427), and with sawing strokes a well rounded flap is cut from the palmar skin. (Fig. 428).

Fig. 427.

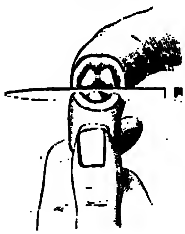


Fig. 428.

b. DISARTICULATION OF THE SECOND PHALANX OF THE FINGER.

(With formation of a flap from within outwards, by transfixion.)

1. The hand is held in supination opposite the operator, who seizes the end of the finger in extension, and thrusts a narrow knife between the skin and the joint, from one side to the other, under the crease at the joint, and carries the blade with sawing strokes first towards him, then upwards, so that a well-rounded flap is formed (Fig. 429).

2. The flap is turned back, the joint over-extended, and the knife, beginning at the wound, divides with one stroke the lateral ligaments, the capsule, and the skin at the dorsal side of the joint (Fig. 430.)

Fig. 429.

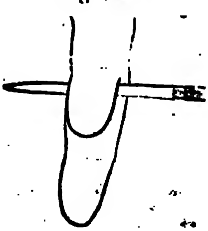
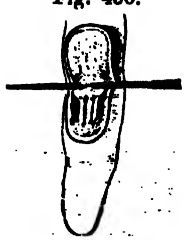


Fig. 430.



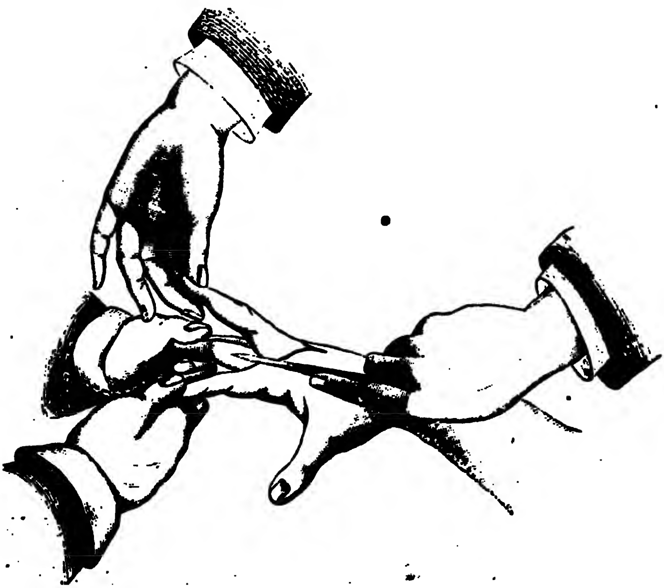
c. DISARTICULATION OF THE FINGER AT THE METACARPO-PHALANGEAL ARTICULATION.

1. OVAL METHOD.

1. The operator stands at the left of the limb, turns his back to the patient, and while an assistant separates the adjoining fingers,

Fig. 431.

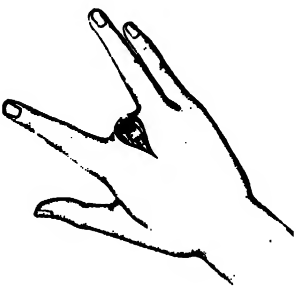
Fig. 432.



seizes the injured finger with his left hand, and over-extends it so that he can see the palmar surface. He then applies a narrow knife (from the right side) to the palmar surface of the first phalanx, cuts the soft parts here transversely at the level of the stretched web, carries the knife around the right side of the phalanx to the dorsum, and then upwards in a curve to the head of the metacarpal bone — which has been marked beforehand (Fig. 431).

2. The knife is then passed through under the left hand, at the left side of the finger, to the beginning of the first incision, inserted down to the bone, and carried at the level of the web around the left side of the first phalanx to its dorsal aspect, and there drawn upwards in a curve to the end of the first incision (Fig. 432).

Fig. 433.

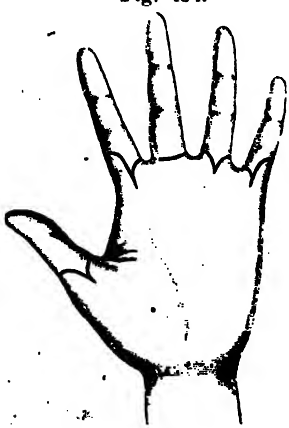


3. Both incisions are repeated in the same order, but penetrating more deeply towards the joint, and while the finger is drawn to the opposite side they divide the tendons, the lateral ligaments, and the capsule of the joint. The wound presents the shape of the heart on playing cards (Fig. 433).

2. METHOD BY FLAPS.

1. This method is best suited to the thumb, index, and little fingers, because these are more accessible from the side.

Fig. 434.



A large half-oval flap, the base of which lies at the level of the joint, is cut from the skin of the palmar, dorsal, or lateral sides of the first phalanx and retracted.

2. A smaller skin flap is then formed on the opposite side, and also turned back (Fig. 434).

3. Finally, the tendons are divided at the level of the articulation, and the latter opened on every side.

NB. The disarticulation is represented on the ring finger with two small lateral flaps, on the middle finger with the oval incision as seen on the palmar surface. (Fig. 434).

d. DISARTICULATION OF THE THUMB AT THE CARPAL JOINT.

1. OVAL METHOD.

1. The first incision begins on the ulnar side of the first phalanx, at the level of the web, is carried obliquely over the phalangeal-metacarpal joint to the radial side of the metacarpal bone, and along this to its base.

2. The second incision is carried from the same point around to the radial side, and meets the first in the middle line of the metacarpal bone (Fig. 435).

Fig. 435.

3. By repeated cuts in the same direction along the bone, the latter is isolated from the muscles.

4. The articulation between the trapezium and the metacarpal bones is opened from the ulnar side, and in so doing, the edge of the knife must be kept close to the base of the metacarpal, so as not to open the joint between the trapezium and the metacarpal bone of the fore-finger — which communicates with the other carpal joints.

5. The division of the ligaments of the radial side (Fig. 436) completes the operation, which leaves a linear scar (Fig. 437).

Fig. 436.

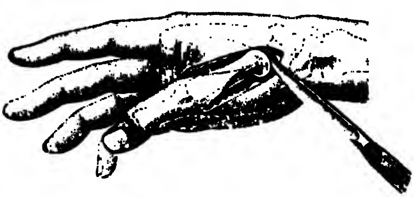


Fig. 437.

2. METHOD BY A LATERAL FLAP, ACCORDING TO V. WALTHER.

1. The thumb is abducted, the knife placed at the middle of the web, and carried upwards with sawing strokes between the first and second metacarpal bones until it reaches the ulnar border of the first metacarpal (Fig. 438).

2. Avoiding the joint between the metacarpal bone of the fore-finger and the os trapezium, the point of the knife is carefully passed behind the base of the bone, and the carpo-metacarpal joint is thus opened.

3. The thumb can then be more strongly abducted, the knife passes through the articulation to the radial side of the metacarpal

bone, and is carried downwards again along this border, forming a radial flap, the rounded end of which lies at the level of the web (Fig. 439).

Fig. 438.

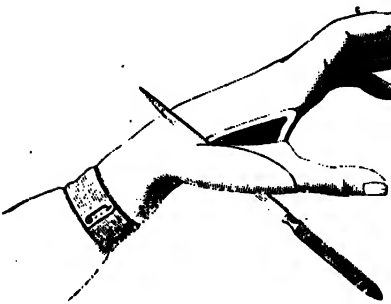
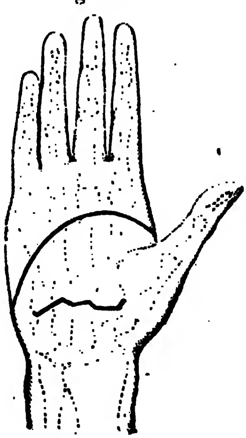


Fig. 439.

e. DISARTICULATION OF THE METACARPAL BONES OF THE FINGERS WITH PRESERVATION OF THE THUMB.

1. A semicircular flap of skin is outlined in the palm of the hand with an oblique curved incision, which begins at the web of the thumb, and ends at the ulnar border of the base of the fifth metacarpal bone (Fig. 440). This flap can also be formed from within outwards by transfixion at its base (Fig. 441).

Fig. 440.



Palmar incision.

Fig. 441.

Formation of palmar flap by transfixion.

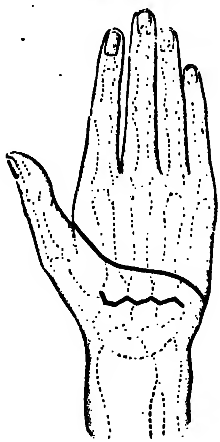
Disarticulation of the metacarpal bones of the fingers.

2. An incision is made on the back of the hand, beginning at the web of the thumb, and passing obliquely upwards to the upper third of the second metacarpal, and thence over the three inner metacarpal bones to the ulnar border of the hand, where it meets the palmar incision (Fig. 442).

3. After both flaps have been dissected up to the neighborhood of the carpo-metacarpal articulations, the latter are opened from the ulnar side, the hand being held in strong adduction, until even the articulation between the second metacarpal and the os trapezium is severed. In so doing, the cuts must be made very carefully and always against the two bones, to avoid injury of the joint between the os trapezium and the metacarpal of the thumb.

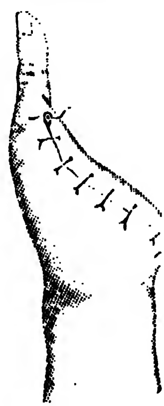
4. The preservation of the thumb is of the greatest advantage for the usefulness of the stump (Fig. 433).

Fig. 442.



Dorsal incision.

Fig. 443.



Appearance of stump.

Disarticulation of the metacarpal bones of the fingers.

f. DISARTICULATION AT THE WRIST.

1. CIRCULAR METHOD.

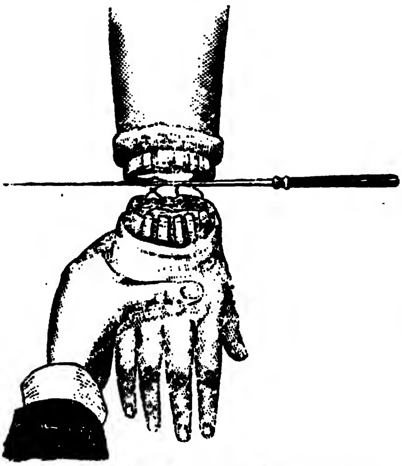
1. A circular incision surrounds the hand at the middle of the metacarpus, $1\frac{1}{2}$ inch below the styloid processes.

2. The skin is dissected up with vertical cuts, until it can be turned back above the styloid processes like a cuff.

3. The hand is pronated and strongly flexed; an incision, slightly convex above, carried across the dorsum from one styloid process to the other, divides the extensor tendons and opens the wrist joint.

4. The lateral ligaments are divided below each styloid process; and finally, the anterior wall of the capsule and all the flexor tendons are cut through with one stroke (Figs. 444 and 445).

Fig. 444.



Disarticulation at the wrist by the circular method.

Fig. 445.

Stump after disarticulation at the wrist by the circular method.

2. METHOD BY FLAPS.

1. The operator seizes the lower part of the hand, pronates and flexes it, and makes a semicircular incision from the point of one styloid process to that of the other, across the middle of the dorsum (Fig. 446).

2. The flap of skin is dissected from the extensor tendons, retracted, and the joint opened as in the circular method.

3. The bundle of flexor tendons is pressed into the wound by the point of the index finger in the palm, and carefully divided by drawing the knife back and forth; and then a small flap of skin is cut from the palmar tissues, from the wound outwards (Fig. 447).

NB. It is well to mark out the palmar flap at the beginning of the operation by an incision in the skin.

3. METHOD BY A RADIAL FLAP (Walther, 1810).

1. A semicircular flap is cut from the skin which covers the metacarpal region of the thumb, the base of which surrounds the radial third of the carpus, and the point of which reaches the base of the first phalanx.

Fig. 446.

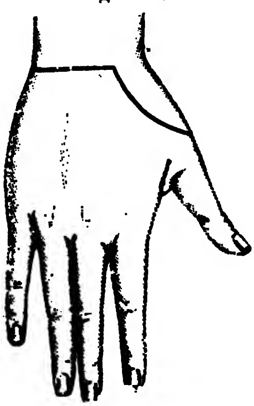
Fig. 447.

Disarticulation at the wrist, flap method (Ruysch).

2. After the flap has been dissected from the muscles of the thumb and retracted, a semicircular incision surrounds the other two-thirds of the carpus on the ulnar side (Fig. 448).

3. The skin is well retracted, and the carpus separated from the bones of the forearm (Fig. 449).

Fig. 448.



Incision.

Fig. 449.

Appearance of the stump.

Disarticulation at the wrist, according to Walther.

g. AMPUTATION OF THE FOREARM.

1. METHOD BY CIRCULAR FLAPS OF SKIN.

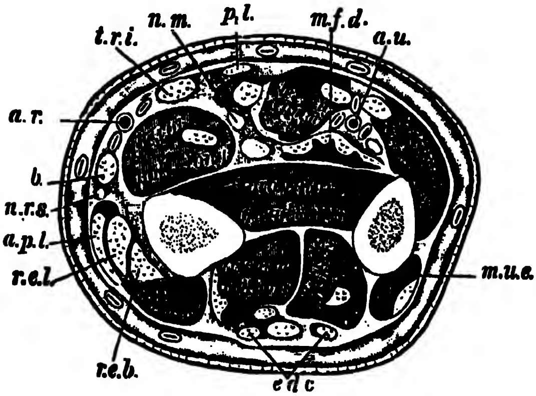
(See page 218.)

2. MODIFIED FLAP METHOD.

(See page 220.)

Fig. 450.

Transverse section of the right forearm in its lowest third.

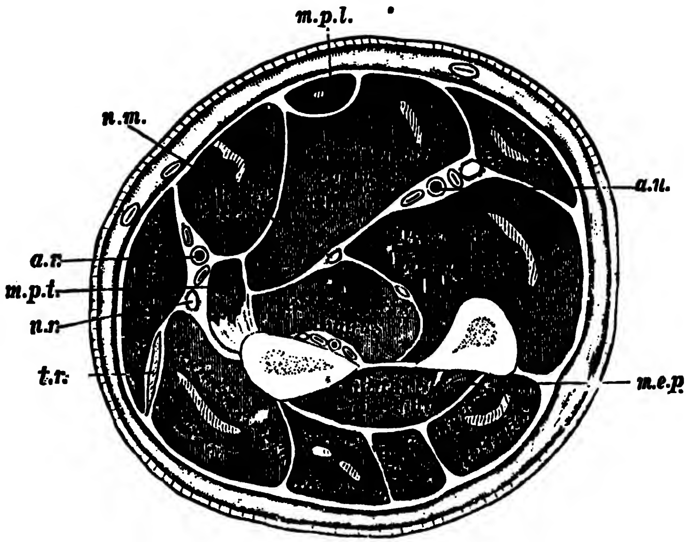


p. l.	palmaris longus.
n. m.	median nerve.
t. r. i.	tendon of flexor carpi rad.
a. r.	radial artery.
b.	supinator longus.
n. r. s.	radial nerve.
a. p. l.	extens. os. metac. pollicis.
r. e. l.	extensor carpi rad. long.
r. e. b.	extensor carpi rad. brev.
e. d. c.	extensor commun. digit.
m. u. e.	extensor carpi ulnaris.
a. u.	ulnar artery.
m. f. d.	flexor commun. digit. profundus.

NB. In the figure, ulnaris internus = flexor carpi ulnaris; extensor poll. brev. = ext. primi internod. poll.; and ext. poll. long. = ext. secundi internod. poll.

Fig. 451.

Transverse section of the right forearm through its middle.

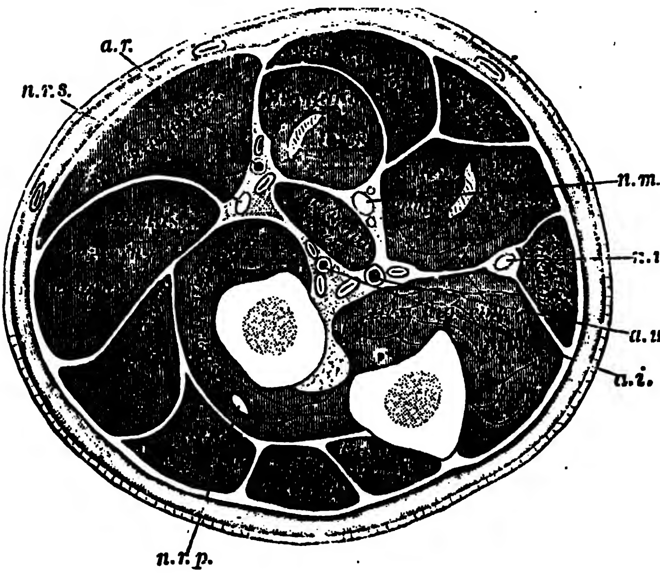


m. p. l.	palmaris longus.
	median nerve.
	radial artery.
m. p. t.	pronator radii teres.
n. r.	radial nerve.
t. r.	tendon of ext. carp. rad. long.
m. e. p.	extens. secundi internod. poll.
a. u.:	ulnar artery.

NB. In the figure, radialis internus = flex. carpi rad.; brachio-radialis = supinator longus; radialis externus brevis = extens. carpi rad. brev.; adductor long. poll. = ext. os. metacarpi poll.; ulnaris intern. = flex. carpi ulnar.; ulnaris externus = ext. carpi. ulnar.; extens. dig. quint. = ext. minimi dig.

Fig. 452.

Transverse section of the right forearm in its uppermost third.



a. r.: radial artery.
n. r. s.: radial nerve.
n. r. p.: posterior inteross. nerve.
a. u.: ulnar artery.
n. u.: ulnar nerve.
n. m.: median nerve.
a. i.: anterior interosseous artery.

NB. In the figure, brachioradialis = supinator longus; radialis extern. longus and brevis = extensor carpi rad. long. and brev.; radialis internus = flexor carpi rad.; ulnaris internus = flex. carp. ulnar.; ulnar. externus = extens. carpi ulnar.; ancon. quart. = anconeus.

h. DISARTICULATION AT THE ELBOW.

1. CIRCULAR METHOD.

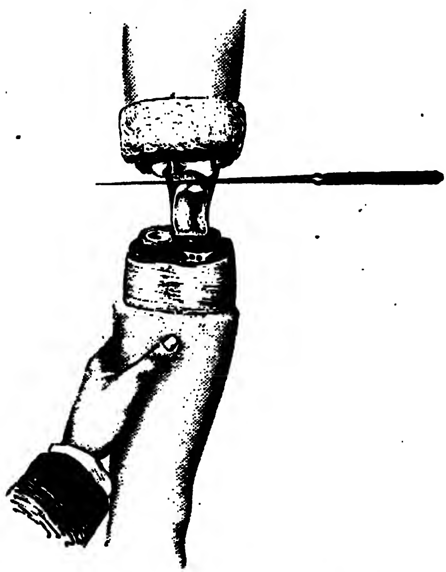
1. A circular incision divides the skin $1^1/_2$ inch below the condyles of the humerus; the cuff flap is dissected up and retracted.

2. A transverse cut freely opens the over-extended joint.

3. A cut above the head of the radius divides the external lateral ligament; another below the internal condyle divides the internal lateral ligament.

4. The joint gapes widely; the olecranon is pressed into the wound: and a cut above the point of the latter divides the tendon of the triceps (Figs. 453 and 454).

Fig. 453.



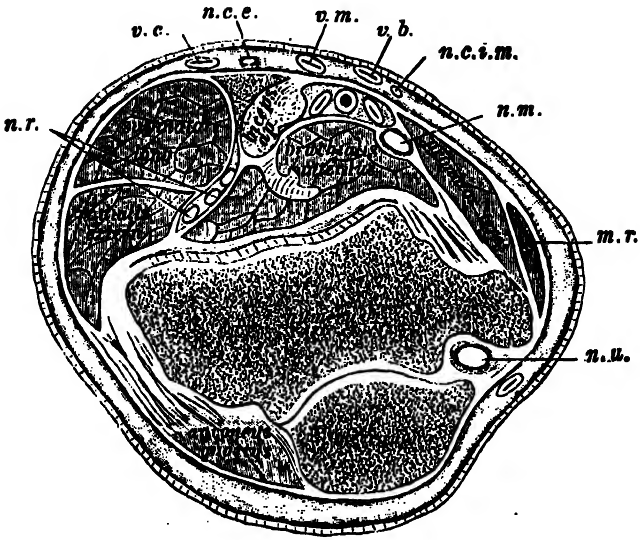
Disarticulation at the elbow by the circular method.

Fig. 454.

Appearance of the stump after disarticulation at the elbow by the circular method.

Fig. 455.

Transverse section of the right elbow joint at the level of the condyles.



n. c. e.: ext. cutaneous nerve.
v. c.: cephalic vein.
n. r.: musculo-spiral nerve.
v. m.: median vein.
v. b.: basilic vein.
n. c. m. i.: greater int. cutan. nerve.
n. m.: median nerve.
m. r.: flex. carpi radialis.
n. u.: ulnar nerve.

NB. In the figure, radialis externus = ext. carp. rad. long.; brachialis internus = brach. anticus; anconeus quartus = anconeus.

2. METHOD BY FLAPS.

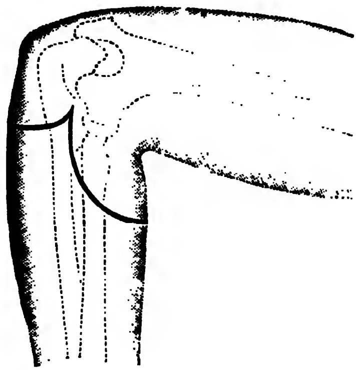
1. A curved incision, which begins 1 inch below one condyle and ends 1 inch below the other, outlines on the anterior surface of the forearm a large semicircular flap of skin, which is dissected up and retracted.

2. The arm is strongly flexed at the elbow, and rotated so that the back part of the joint is directed forwards.

3. A slightly curved incision above the olecranon exposes its point (Fig. 456).

4. A transverse cut from one condyle to the other divides the tendon of the triceps and both lateral ligaments; a second divides all the soft parts on the anterior side of the articulation.

Fig. 456.



Disarticulation at the elbow — method by flaps.

i. AMPUTATION OF THE ARM.

1. CIRCULAR METHOD OF CELSUS.

(See page 217.)

2. METHOD BY CIRCULAR SKIN-FLAP.

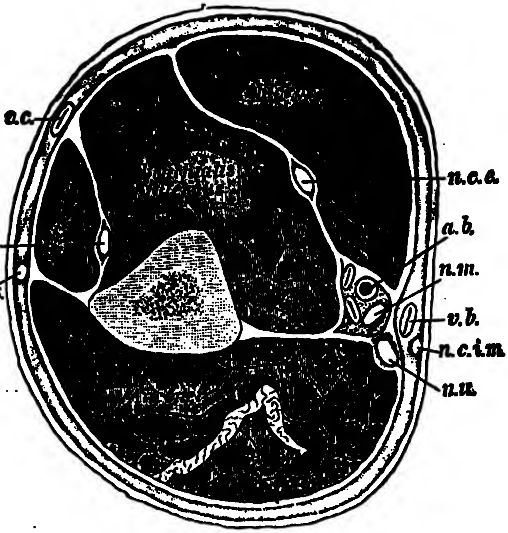
(See page 218.)

3. MODIFIED FLAP METHOD.

(See page 220.)

Fig. 457.

Transverse section of the right arm in its lowest third.

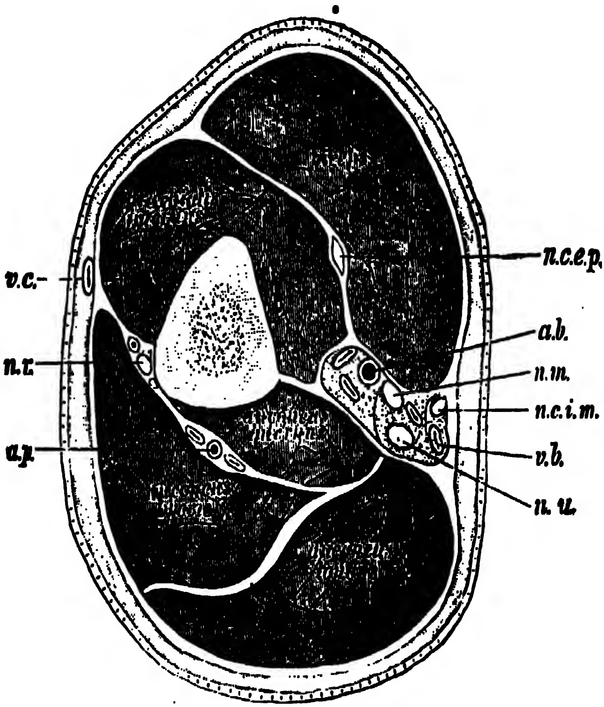


v. c.	cephalic vein.
n. r.	musculo-spiral nerve.
n. c. e. s.	ext. sup. cutaneous nerve.
n. c. e.	ext. cutaneous nerve.
a. b.	brachial artery.
n. m.	median nerve.
v. b.	basilic vein.
n. c. i m.	greater int. cutan. nerve.
n. u.	ulnar nerve.

NB. In the figure, brachialis internus = brachialis anticus; anconei = triceps.

Fig. 458.

Transverse section of the right arm in its middle third.

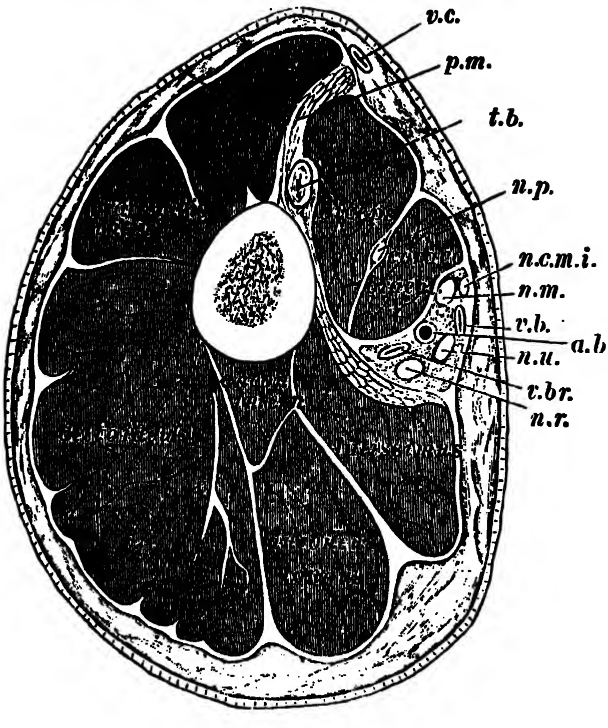


v.c.: cephalic vein.
n.r.: musculospiral nerve.
a.p.: profunda artery.
n.c.e.p.: ext. cutan. nerve.
a.b.: brachial artery.
n.m.: median nerve.
n.c.i.m.: greater int. cutan. nerve.
v.b.: basilic vein.
n.u.: ulnar nerve.

NB. In the figure, brachialis internus = brach. anticus; anconeus internus, brevis, and longus = triceps, internal, external, and long heads.

Fig. 459.

Transverse section of the right arm below the axilla.



ephalic vein.
p. m.: ectoralis major.
t. b.: endon of the biceps.
n. p.: xternal cutaneous nerve.
n. c. m. i.: greater int. cutan. nerve.
n. m.: nedian nerve.
v. b.: asilic vein.
a. b.: rachial artery.
n. u.: ulnar nerve.
v. br.: rachial vein.
n. r.: musculo-spiral nerve.

NB. In the figure, brachialis internus = brach. anticus; anconeus internus and longus = triceps, internal and long heads.

k. DISARTICULATION OF THE ARM AT THE SHOULDER.

1. METHOD BY FLAPS.

1. The patient lies at the edge of the table, half turned upon his sound side, with the upper part of his body somewhat elevated. The more nearly in a sitting posture he is placed, the more convenient

it is for the operator, but the more dangerous for the administration of chloroform (see page 144).

2. On the outer surface of the shoulder, a square flap with rounded corners is outlined with the knife. The base of the flap extends

Fig. 460.

Disarticulation at the shoulder -- method by flaps.

from the coracoid process to the root of the acromion, and the broad lower edge extends below the lower border of the deltoid muscle (Fig. 460).

3. With bold sweeps of the knife, which pass continually deeper into the deltoid, the flap is dissected up to the acromion, and turned back so as to expose the outer surface of the shoulder joint.

4. A bold cut upon the head of the humerus (which is forced upwards) above the two tuberosities, divides the capsule and the tendons passing over it.

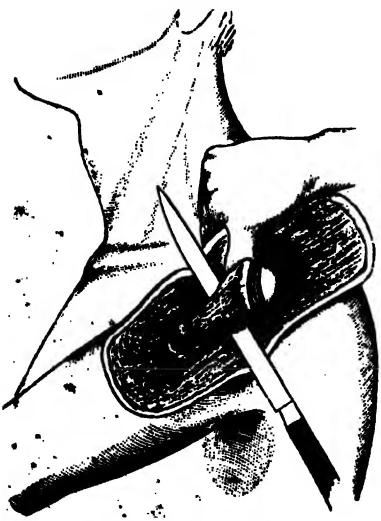
5. The head of the humerus is pressed outwards, and the knife, applied behind it, cuts through the posterior part of the capsule.

6. The operator draws the head of the humerus towards him with his left hand, carries the knife with long sawing strokes along the inner side of the bone, down to $2^1/_4$ inches below the fold of the axilla, then turns the edge inwards (towards the thorax) and with one stroke divides all the soft parts — in which are contained the large vessels and nerves.

7. In cases in which it is impossible to control the supply of blood by compression of the subclavian, before the completion of the last cut, an assistant must thrust his hand into the wound from above, and compress the axillary artery against the skin with his thumb (Fig. 461).

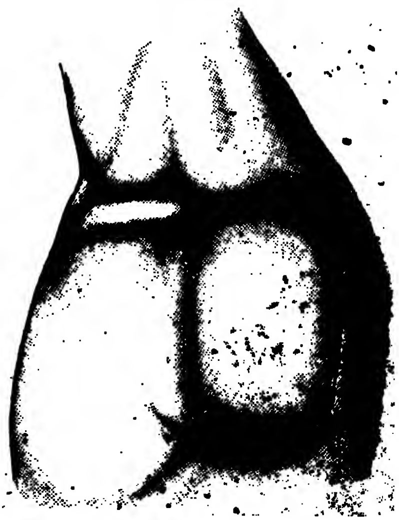
8. Fig. 462 shows the appearance of the wound after it has been closed by sutures.

Fig. 461.



Formation of the second (internal) flap.

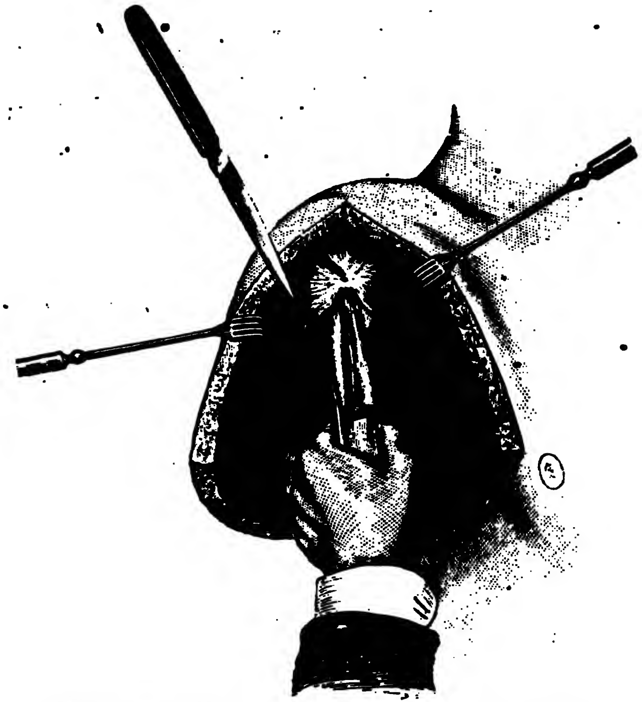
Fig. 462.



Appearance of stump.

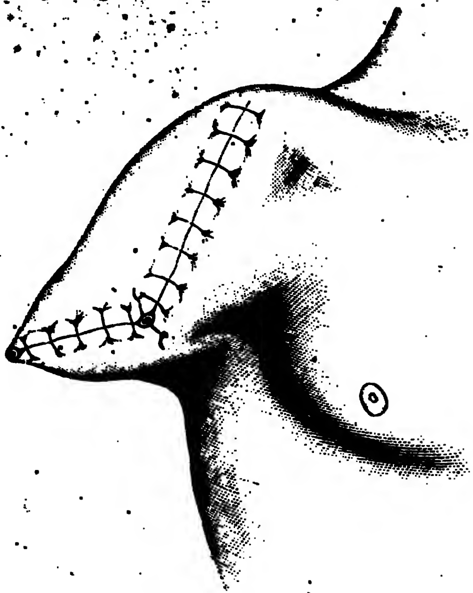
Disarticulation at the shoulder — method by flaps.

Fig. 463.



Disarticulation at the shoulder by the circular method.

Fig. 464.



Stump after disarticulation by circular method.

2. CIRCULAR METHOD.

1. The arm is abducted. A circular incision at the level of the lower border of the deltoid muscle divides all the soft parts down to the bone.

2. The bone is sawed off at the same level; all injured vessels are ligated.

3. A longitudinal incision, from the anterior border of the acromion down to the circular incision, divides all the soft parts down to the bone.

4. The lower end of the stump of the bone is seized with a strong bone forceps or with the left hand, and, while an assistant separates with sharp hooks the edges of the wound made by the longitudinal incision, the operator frees the bone from the articulation by the aid of strong rotary movements (Fig. 463). This isolation is accomplished by short cuts always directed against the bone; or, in suitable cases, by detaching the periosteum with elevator and raspatory.

5. Fig. 464 shows the appearance of the stump. The lower corners of the skin flaps can be cut rounded, if desired.

AMPUTATIONS AND DISARTICULATIONS OF THE LOWER EXTREMITY.

a. DISARTICULATION OF THE TOES.

The toes are removed in the same way as the fingers (pages 229—235).

b. DISARTICULATION OF ALL THE TOES IN THE METATARSO-PHALANGEAL ARTICULATION.

1. While the left hand seizes all the toes together, and bends them strongly upwards, a curved incision, which (in the left foot) begins at the internal border of the first metatarso-phalangeal joint, and ends at the external border of the same joint of the fifth toe, is made in the furrow between the sole of the foot and the base of the toes. (On the right foot this is reversed.) (Fig. 465).

2. The toes being strongly bent towards the sole, a similar incision is made on the dorsum across the base of all of them, its ends meeting the ends of the first (Fig. 466). Both cuts penetrate between the toes into the middle of the web.

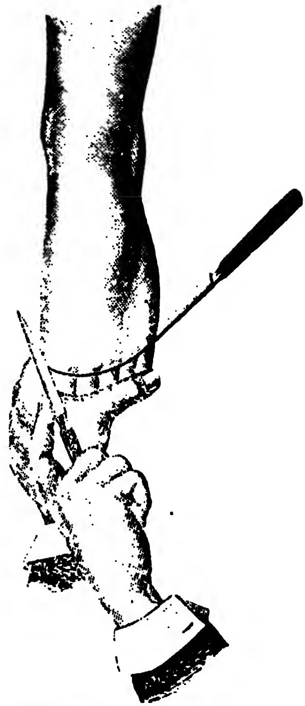
3. The two semicircular flaps are then dissected up as far as the heads of the metatarsal bones.

4. Each toe is separately freed, the sesamoid bones at the head of the first metatarsal bone being left in situ.

Fig. 465.

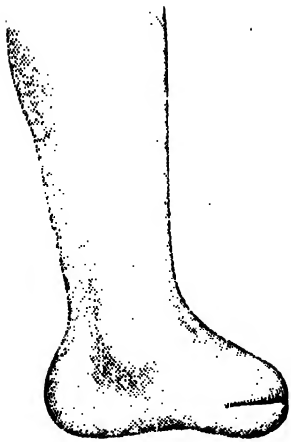
Disarticulation of all the toes.
Plantar incision.

Fig. 466.



Disarticulation of all the toes.
Dorsal incision.

Fig. 467.



Stump after disarticulation of all the toes.

5. If there is not enough skin to easily cover the very prominent heads of the metatarsals, the latter can be cut off, one at a time, with the phalangeal saw.

6. Fig. 467 shows the appearance of the stump.

c. AMPUTATION OF ALL THE METATARSAL BONES.

1. A curved incision is made along the anterior marginal furrow of the sole from one border of the foot to the other, and the semicircular flap dissected back to the point where the amputation is to be made.

2. A smaller semicircular flap is cut on the back of the foot, the ends of which meet those of the plantar flap at the sides of the foot. Instead of the dorsal flap, a cut can be made half way around

as in the circular method, if there is enough skin in the sole to cover the stump.

3. At the base of both flaps the soft parts on and between the metatarsal bones are carefully divided with a narrow knife.

4. The soft parts are strongly retracted with narrow strips of carbolized gauze or linen, drawn through between the bones by forceps, and all the bones sawed through at once, close to the point up to which they have been isolated (Figs. 468 and 469).

Fig. 468.

Sawing the bones.

Fig. 469.

Appearance of the wound after the bones have been sawed off.

Amputation of the foot through the metatarsal bones.

d. DISARTICULATION OF THE GREAT TOE WITH ITS METATARSAL BONE.

1. The **oval incision** is made in the same way as has been described for the disarticulation of the thumb (page 233). On account of the great breadth of the base of the first metatarsal, it is well to make a transverse incision over the joint, which lies about $1^1/_2$ inch in front of the projecting tuberosity of the scaphoid bone, at right angles with the oval incision at the upper end of the latter (Fig. 470), and to dissect back the upper and lower flaps so formed, until the entire bone and the joint are exposed.

Fig. 470.

Disarticulation of the great toe with its metatarsal bone.

2. The tendons of the extensor proprius, and the flexor longus pollicis are cut through at the joint, the latter opened on the dorsal

side, and, the bone being strongly rotated to the opposite side, its connections with the first cuneiform bone are severed.

e. DISARTICULATION OF THE FIFTH TOE WITH ITS METATARSAL BONE.

1. The **flap method** can be employed here in the same way as has been already described for the disarticulation of the thumb (page 233).

2. The left hand strongly abducts the fifth toe from the fourth, while the right hand carries a narrow knife from the web upwards between the two metatarsal bones with a sawing motion, until it meets with resistance.

3. The ends of the incision must be extended $^1/_2$ inch upwards, both on the dorsum and on the sole of the foot.

4. With strong abduction of the fifth metatarsal bone, its base must be first separated from that of the fourth metatarsal, then from the cuboid.

5. The knife is then carried around the tuberosity of the fifth metatarsal where it projects above, and thence downwards along the outer border of the bone, and close to it, with sawing strokes. It thus forms a tongue-shaped outer flap, the point of which must be rounded off exactly at the level of the first incision in the web (Fig. 471).

Fig. 471.

Disarticulation of the fifth toe with its metatarsal bone.

f. DISARTICULATION AT THE TARSO-METATARSAL ARTICULATION ACCORDING TO LISFRANC (Fig. 472).

1. At the outer border of the foot, must be found the joint between the cuboid bone and the fifth metatarsal, which lies directly in front of the tuberosity of the latter; and at the inner border of the foot, the articulation between the first cuneiform and the first metatarsal bones, which is situated $1^1/_2$ inch in front of the tuberosity of

Fig. 472.

Disarticulation in the tarso-metatarsal joint, according to Lisfranc.

the scaphoid. These two points are to be marked with india ink, or a small puncture with the knife.

2. The foot being elevated, a large semicircular flap is outlined with the knife on the sole of the foot, from one of these points to the other (from left to right), the convexity of the flap being situated over the heads of the metatarsal bones.

3. The foot is depressed and strongly extended, and the knife carried across the dorsum of the foot from one end of the sole flap to the other in a slightly curved line, cutting through all the soft parts down to the bone (Fig. 473).

Fig. 473.

Fig. 474.

4. The small dorsal flap is retracted, and repeated trials are made with the point of the knife to open the joint which lies farthest

to the left (in the right foot, the fifth metatarsal joint), while the left hand strongly depresses the toes.

5. As soon as the joint gapes, the knife is carried on in a slight curve, convex anteriorly, opens the fourth and third joints (a), slips over the base of the second metatarsal bone, and opens the first joint (c) (Fig. 474).

6. The joint of the second metatarsal bone, which lies about $^1/_3$ inch higher than that of the first, is opened by a small transverse cut (b); the lateral connections of the bone with the first and second cuneiform bones, between which its base is inserted, are divided with the point of the knife — the edge of the blade being directed upwards (Fig. 475).

Fig. 475.

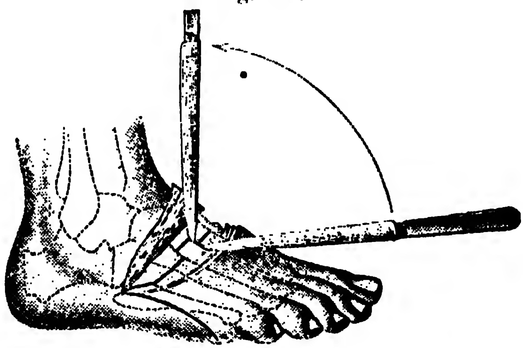


Fig. 476.

Fig. 477.

Fig. 478.

Lisfranc's amputation.

7. Now all the articulations open more widely, the knife divides the rest of the ligaments at the sides and towards the sole, and cuts through the greater part of the muscular tissues in the sole; its edge is then directed forwards, to complete the plantar flap (Fig. 476).

Fig. 477 shows the appearance of the wound before it is closed, and Fig. 478 the appearance of the stump.

g. DISARTICULATION THROUGH THE TARSUS, ACCORDING TO CHOPART.

1. The disarticulation takes place through the joint between the scaphoid bone and the head of the astragalus internally, and between the cuboid and the os calcis externally (Fig. 479).

Fig. 479.

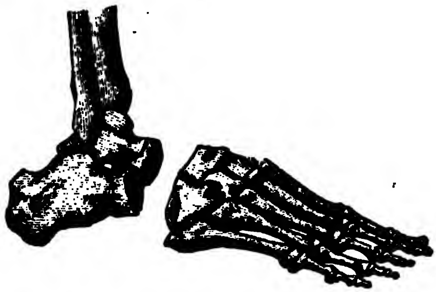


Fig. 481.

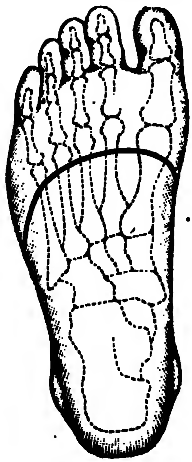


Fig. 480.

Fig. 483.

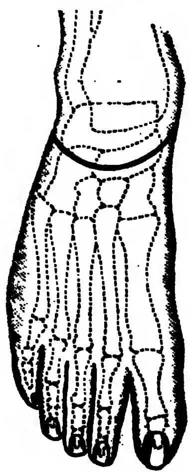
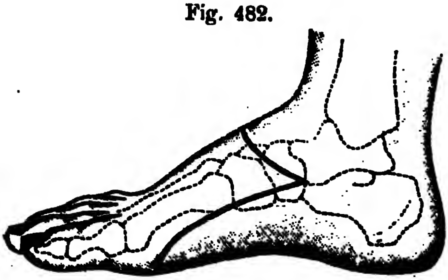


Fig. 482.



Chopart's amputation.

2. The line of the joint is found on the inner border of the foot, $^1/_3$ inch above the tuberosity of the scaphoid, and on the outer border $^3/_4$ inch above the tuberosity of the fifth metatarsal bone, and is marked before beginning the operation.

3. The foot being elevated, a curved incision is carried across the sole, passing forwards from the point marked nearest the left hand to a point situated behind the heads of the metatarsal bones as far as the thickness of the thumb, and then transversely across the sole; and, finally, at the outer side of the foot, backwards to the point marked nearest the right hand (Figs. 480 to 482).

4. The foot is lowered and pressed strongly downwards, and the knife is applied at the left angle of the wound and carried in a slightly curved line across the dorsum of the foot, dividing only the skin, to the right angle of the plantar incision (Fig. 483).

Fig. 484.

Completing the plantar flap.

Fig. 485.

Appearance of the stump.

Chopart's amputation.

5. The small dorsal flap is strongly retracted, a bold transverse cut across the joint divides all the tendons and penetrates at once into the articulation, and it is most certain to first enter it above the tuberosity of the scaphoid — which is plainly to be felt.

6. The joints open with a cracking sound under the edge of the knife as it passes over the somewhat ∼-shaped line of the articulation. The point of the knife divides the ligaments, put on the stretch everywhere, the plantar side last of all, until the anterior part of the foot can be bent entirely back towards the heel.

7. After the plantar flap has been cut a little deeper at both sides of the foot, the blade of the knife is applied in the wound to the inferior surface of the isolated scaphoid and cuboid bones with the edge directed anteriorly, and carried forwards with a sawing motion to complete the plantar flap (Fig. 484).

8. Fig. 485 shows the appearance of the stump.

h. SUBASTRAGALOID DISARTICULATION OF THE FOOT ACCORDING TO MALGAIGNE.

1. Two lateral flaps are formed by an incision which begins behind, close above the tuberosity of the os calcis, dividing the tendo Achillis from it, then passes around the external malleolus in a sweeping curve, crosses the lower half of the os calcis (Fig. 486), thence

Fig. 486.

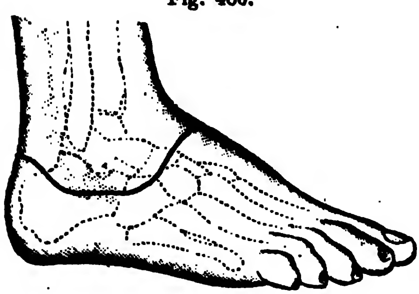
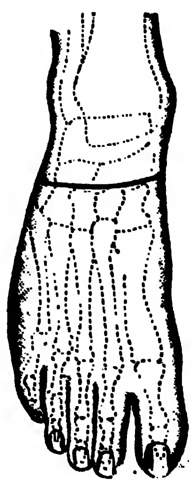


Fig. 487.



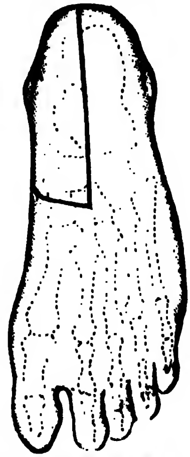
Subastragaloid disarticulation of the foot according to Malgaigne.

rises directly across the middle of the cuboid to the dorsum of the foot, passes over the anterior border of the scaphoid (Fig. 487), and de-

scends vertically at the middle of the inner border of the foot (Fig. 488) until it reaches the center of the sole (Fig. 489). Thence, bending in a right angle, it runs backwards, and meets the commencement of the incision at the inner border of the tendo Achillis.

Fig. 488.

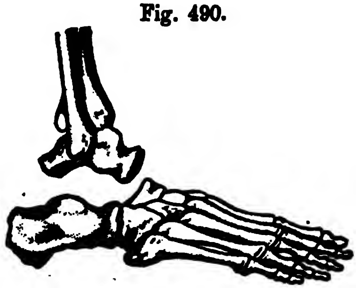
Fig. 489.



Subastragaloid disarticulation of the foot according to Malgaigne.

2. The two flaps are dissected from the bone, until both lateral surfaces of the os calcis and of Chopart's joint are exposed. In dissecting them up, care must be taken not to come too near the lower end of the malleoli, for fear of injuring the ankle joint.

Fig. 490.



Subastragaloid disarticulation of the foot.

Fig. 491.

Appearance of stump.

3. The anterior part of the foot is removed by cutting through Chopart's joint.

4. The anterior end of the os calcis is seized with a bone forceps, and while the bone is drawn downwards and supinated, the external lateral ligament is divided with a narrow knife, $^1/_3$ inch below the point of the external malleolus, and the knife is then inserted into the depression in front of the malleolus, and the strong calcaneo-astragaloid interosseous ligament is severed. Finally, while the os calcis is continuously rotated on its long axis, the posterior calcaneo-astragaloid ligament is divided about 1 inch below the internal malleolus (see the figure of the ligaments, under resection of the ankle).

5. In spite of the very irregular shape of the lower surface of the astragalus (Fig. 490), this operation furnishes a stump which is very useful for walking.

I. DISARTICULATION OF THE FOOT ACCORDING TO SYME.

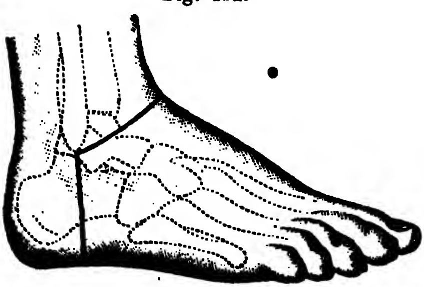
1. The foot, flexed at a right angle with the leg, is well elevated, and a deep incision, penetrating to the bone throughout its course, is made from the apex of one malleolus (that to the left of the operator) to the other, crossing the sole of the foot transversely (Figs. 492 to 494).

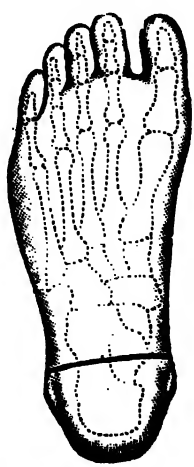
2. The foot is lowered, pressed strongly downwards with the left hand, and a second incision made transversely across the anterior surface of the tibio-tarsal joint from the apex of one malleolus to that of the other (Fig. 495).

3. A transverse cut across the articular surface of the astragalus opens the joint in front; two cuts below the two malleoli divide the

Fig. 493.

Fig. 492.





Disarticulation of the foot according to Syme.

Fig. 494.

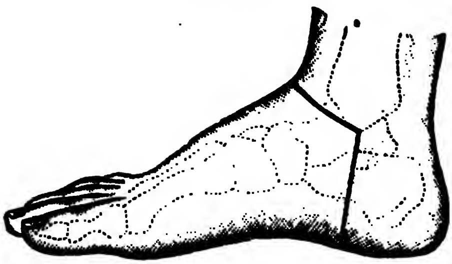
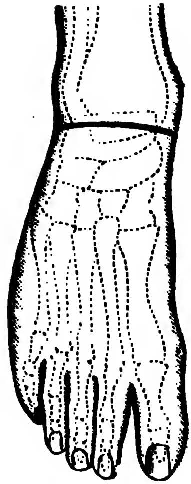


Fig. 495.



Disarticulation of the foot according to Syme.

lateral ligaments, and the upper articular surface of the astragalus comes out freely.

4. While the left hand constantly forces the foot towards the back of the leg, and turns it on its axis alternately one way and the other, the os calcis is dissected from the cap of the heel-flap and divided

Fig. 496.

Disarticulation of the foot according to Syme. — Dissecting out the os calcis.

Fig. 497.

Heel-flap, raw surface.

Fig. 498.

Line of the saw-cut.

Fig. 499.

Fresh stump, anteriorly.

Fig. 500.

Healed stump, laterally.

Syme's disarticulation of the foot.

from the tendo Achillis by cuts which are made close together, and alternately above, and laterally (and, when the bone has been nearly extracted, from below and behind), but always directed against the bone (Fig. 496).

NB. In secondary operations it is well to shell out the os calcis from the periosteum with elevator and raspatory instead of using the knife.

5. The heel-flap and the skin are retracted above the malleoli; and a circular cut, made just above the joint surface of the tibia, divides the rest of the soft parts (tendons and periosteum).

6. The saw cuts across the bone so as to remove only the two malleoli and a thin layer of cartilage from the articular surface of the tibia (Figs. 497 and 498).

Or the malleoli alone may be removed with the bone-cutting forceps, as Syme has done several times.

7. After ligature of all the wounded vessels, the skin is perforated at the outer edge of the tendo Achillis with a narrow knife, a drainage tube drawn through the opening, and then the wound brought together with sutures (Figs. 499 and 500).

k. DISARTICULATION OF THE FOOT ACCORDING TO PIROGOFF.

Amputatio tibio-calcanea osteoplastica.

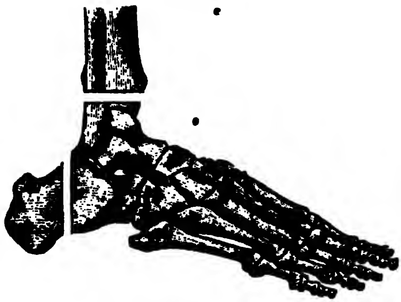
1. The soft parts are divided in the same manner as in Syme's method.

2. After the joint has been freely opened, the foot is bent strongly backwards until the sustentaculum tali appears.

Fig. 501.

Disarticulation of the foot according to Pirogoff — sawing the os calcis.

Fig. 502.



Lines of the saw-cuts.

Fig. 503.

Stump after Pirogoff's amputation.

3. The saw is applied to the upper surface of the os calcis directly behind the sustentaculum tali, and the bone sawed through exactly in the line of the incision in the sole (Figs. 501 and 502).

4. Both malleoli and a thin layer of the articular surface of the tibia are sawed off as in Syme's method.

5. The tendo Achillis is cut across just above its insertion and an opening made in the skin at the same place for the introduction of a drainage tube.

6. Fig. 503 shows the appearance of the stump.

I. GÜNTHER'S MODIFICATION OF PIROGOFF'S METHOD.

1. The incision in the sole begins and ends just in front of the malleoli, and passes transversely across the sole in the neighborhood of the posterior border of the scaphoid bone (Figs. 504 to 506).

2. The dorsal incision forms a small semi-circular flap which reaches to the scaphoid bone (Fig. 507).

3. After the joint has been opened, the soft parts are dissected up, obliquely upwards and backwards, as far as the attachment of the tendo Achillis — in this dissection, any injury to the posterior tibial artery must be carefully avoided.

4. Just in front of the attachment of the tendo Achillis, a metacarpal saw is applied to the os calcis and the bone sawed obliquely from the posterior superior part forwards and downwards.

5. The tibia and fibula are also sawed obliquely — from behind forwards, and from above downwards.

Fig. 504.

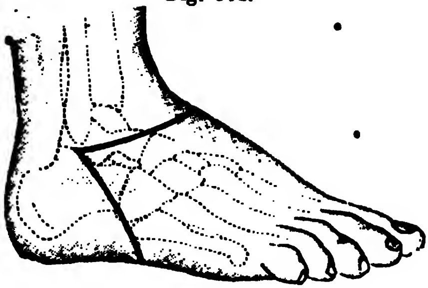


Fig. 505.

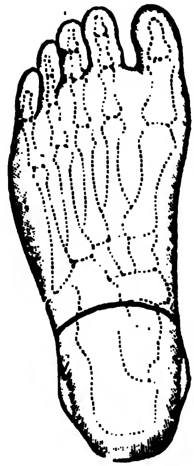


Fig. 506.

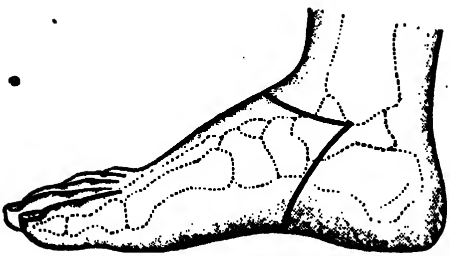


Fig. 507.

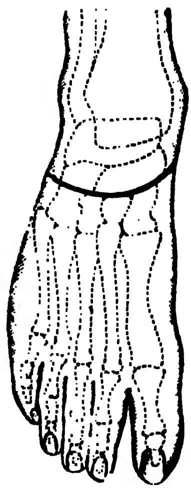
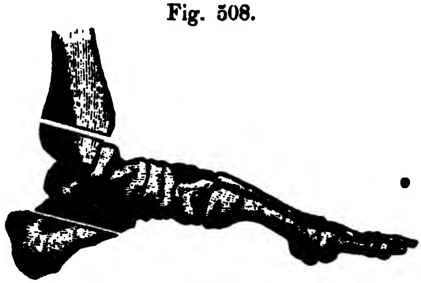


Fig. 508.



Günther's modification of Pirogoff's operation.

6. By this method, the sawed surfaces of the bones can be easily applied to each other without division of the tendo Achillis.

7. In this operation and in the preceding, it is well to bore oblique holes through both bones with a fine awl, and to fasten them together with strong strands of catgut.

m. LE FORT'S MODIFICATION OF PIROGOFF'S OPERATION.

(Altered by the author).

1. The plantar incision begins $^3/_4$ inch below the apex of the external malleolus (on the right foot), runs in a slightly convex line across the sole over the cuboid and scaphoid bones, and ends on the internal side $1^1/_5$ inch in front of and below the internal malleolus (Figs. 509 to 511).

Fig. 509.

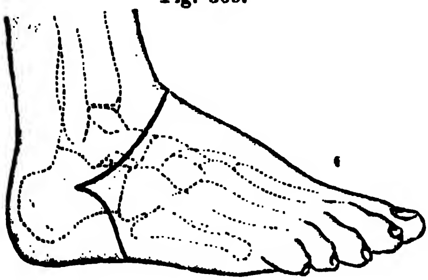


Fig. 510.

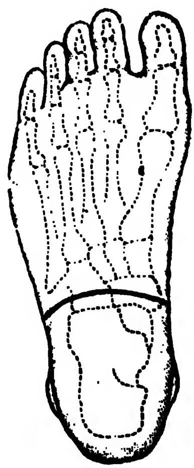
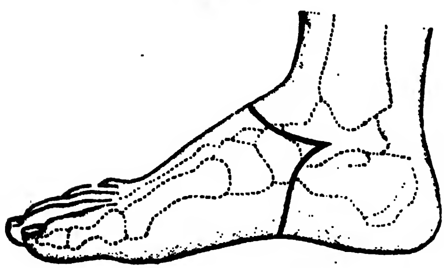


Fig. 511.



Le Fort's modification of Pirogoff's operation.

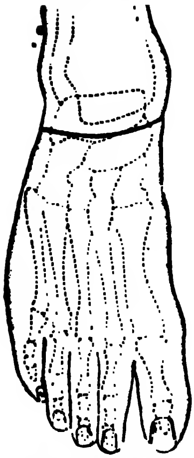
2. The dorsal incision, between the same points, forms a slightly convex flap, the anterior edge of which lies in the line of Chopart's joint (Fig. 512).

3. The dorsal flap is dissected up to the tibio-tarsal joint, and the joint opened as in Pirogoff's operation.

4. The foot is turned backwards, and the upper surface of the os calcis dissected out, sufficiently to allow a narrow saw to be applied behind the upper edge of the tuberosity of the os calcis, so that the superior third of the bone can be removed by a horizontal cut, directed from behind forwards (Fig. 513).

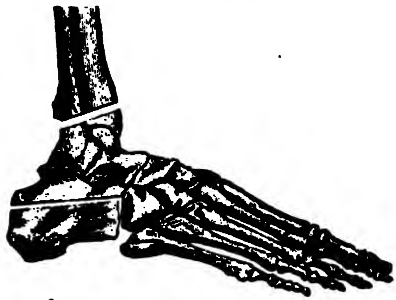
5. As soon as the saw enters Chopart's joint, the bones which form this articulation are separated as in Chopart's operation.

Fig. 512.



Dorsal incision.

Fig. 513.



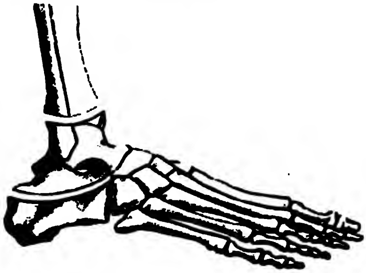
Lines of the saw-cuts.

6. The two malleoli and the lower articular surface of the tibia are sawed off as in Pirogoff's operation.

7. Or the os calcis can be sawed with the narrow saw, so as to form a concave surface; and the bones of the leg, so as to form a convex one — as suggested by von Bruns (Fig. 514).

8. The stump furnished by this method has a very broad surface for walking (Fig. 515).

Fig. 514.



Lines of the saw-cuts according to von Bruns.

Fig. 515.

Stump after Le Fort's operation.

9. In all these operations it is advisable, after the soft parts have been brought together, to fasten the bones to each other by a long steel nail, driven from the sole through the os calcis deep into the tibia. With antiseptic healing of the wound, the sawed surfaces unite quickly, and the nail does not cause suppuration.

n. AMPUTATION OF THE LEG.

1. METHOD BY CIRCULAR SKIN-FLAP.

(See page 218).

2. MODIFIED FLAP METHOD.

(See page 220).

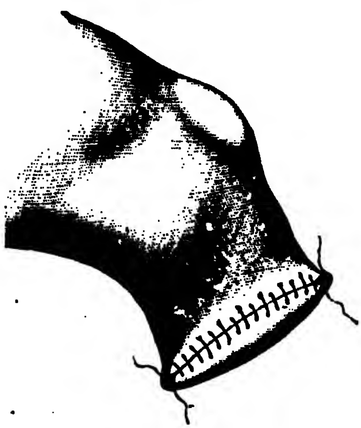
Two lateral flaps of skin (see Fig. 408) are particularly suitable to amputation in the lowest third (above the malleoli).

An anterior skin-flap is liable to be pressed upon from within by the sharp angle of the sawed surface of the tibia.

A posterior skin-flap draws the edges of the wound open by its weight.

The formation of a **lateral flap** with a semi-circular incision on the opposite side (according to von Langenbeck) is very useful for the two upper thirds of the leg. It is only necessary to remember that the base of the skin-flap should be somewhat **less** than half the circumference of the limb at the point of amputation (Fig. 516).

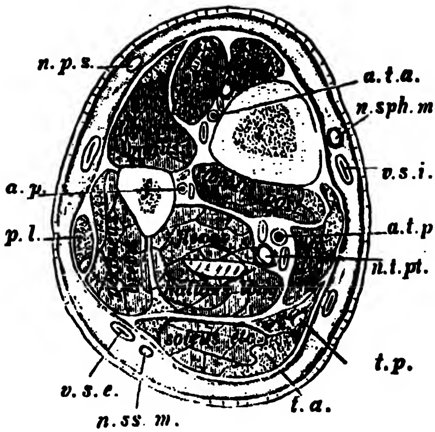
Fig. 516.



Amputation of the leg with one lateral flap.

Fig. 517.

Transverse section of the right leg in its lowest third.

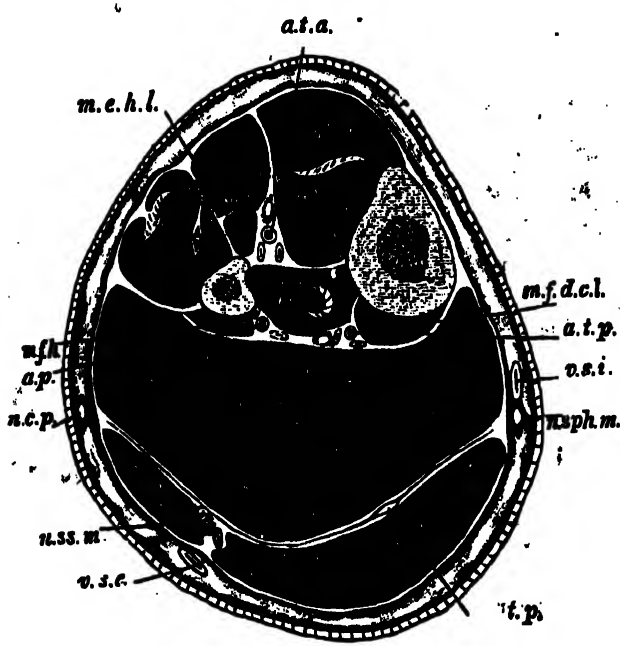


n. p. s.: superficial peroneal nerve.
a. p.: peroneal artery.
p. l.: peroneus longus.
v. s. e.: ext. saphenous vein.
n. ss. m.: ext. saphenous nerve.
t. a.: tendo Achillis.
t. p.: tendon of the plantaris.
n. t. pt.: post. tibial nerve.
a. t. p.: post. tibial artery.
v. s. i.: int. saphenous vein.
n. sph. m.: int. saphenous nerve.
a. t. a.: anterior tibial artery.

NB. In the figure, ext. hal. long. = ext. proprius pollicis; and flexor halucis long. = flex. poll. long.

Fig. 518.

Transverse section of the right leg in its middle third.

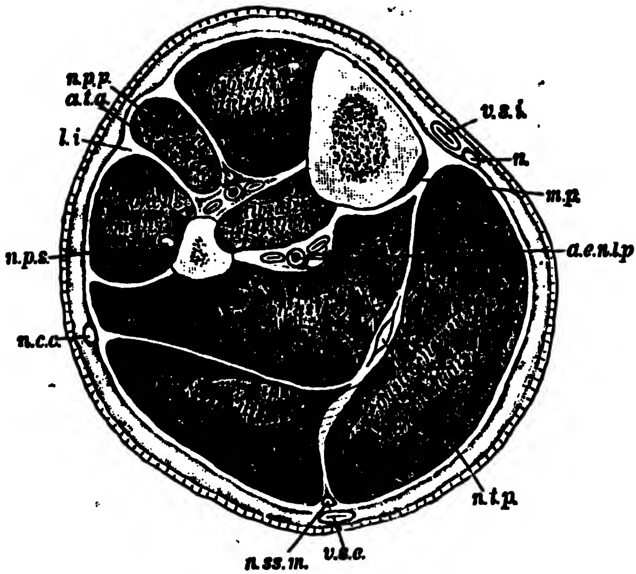


a. t. a.: anterior tibial artery.
m. e. h. l.: extensor proprius pollicis.
m. f. h.: flex. long. poll.
a. p.: peroneal artery.
n. c. p.: ext. post. cutaneous nerve.
n. ss. m.: ext. saphenous nerve.
v. s. e.: ext. saphenous vein.
t. p.: tendon of the plantaris.
n. sph. m.: int. saphenous nerve.
v. s. i.: int. saphenous vein.
a. t. p.: post., tibial artery.
m. f. d. c. l.: flex. long. digitorum.

NB. In the figure, gastrocnemius lateralis and medialis = ext. and int. heads of gastrocnemius.

Fig. 519.

Transverse section of the right leg in its uppermost third.



n. p. p.: anterior tibial nerve.
a. t. a.: anterior tibial-artery.
l. i.: intermuscular aponeurosis.
n. p. s.: musculo-cutaneous nerve.
n. c. c.: post. cutaneous nerve.
n. ss. m.: ext. saphenous nerve.
v. s. e.: ext. saphenous vein.
t. p.: tendo plantaris.
a. e. n. t. p.: post. tibial artery and nerve.
m. p.: popliteus.
n.: int. saphenous nerve.
v. s. i.: int. saphenous vein.

e. DISARTICULATION OF THE LEG AT THE KNEE BY THE CIRCULAR METHOD.

1. A circular incision divides the skin of the leg 3 inches below the patella, the knee being extended. The skin is dissected up on all sides as high as the lower edge of the patella, and the cuff-like flap is retracted.

2. Flexing the knee, the ligamentum patellae is first cut through just below that bone, then the anterior part of the capsular ligament and the two lateral ligaments are divided close to the edge of the femur, so that the semi-lunar cartilages and the greater part of the capsular ligament shall remain attached to the tibia.

3. After the knee has been flexed still farther, the crucial ligaments are cut away from the internal surfaces of both condyles of the femur; the knee is then extended again, and the remaining soft parts at the back part of the joint are divided with one stroke of the knife, from before backwards (Fig. 520).

Fig. 520.

Disarticulation at the knee by the circular method.

4. The wound can be united transversely (Fig. 522); and also in a line from before backwards, so that the cicatrix shall lie between the condyles (Fig. 523).

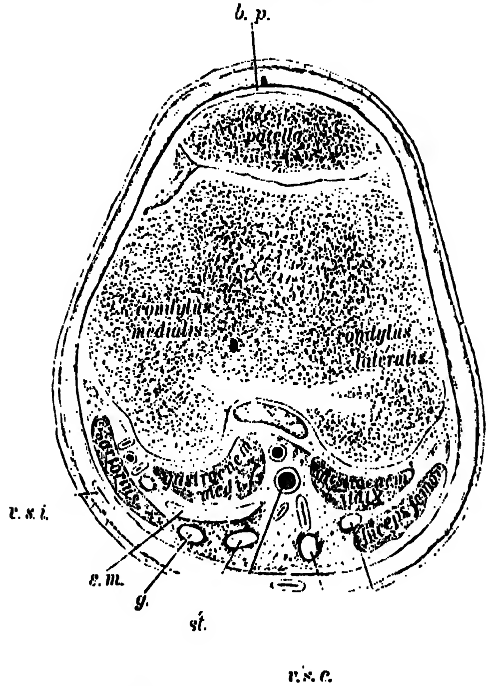
5. If it is desired to remove the patella and the upper pocket of the capsule of the joint, following Billroth, a longitudinal incision is made over the middle of the patella, after the circular incision has been completed, beginning $1^1/_2$ inch above the bone, the patella is cut away from the extensor tendon, the latter is turned upwards, and that part of the capsule which lies underneath it is dissected out.

β. DISARTICULATION OF THE LEG AT THE KNEE BY ANTERO-POSTERIOR FLAPS.

1. A semicircular flap, 3 inches long, is made on the back of the elevated limb by a curved incision which begins $^1/_2$ inch below

Fig. 521.

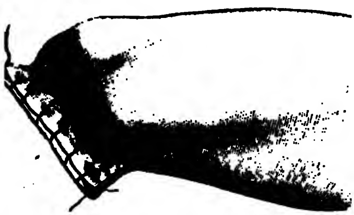
Transverse section of the left thigh at the level of the condyles.



v. s. i.: internal saphen
sm.: semimembranos
g.: gracilis.
st.: semitendinosus.
a. c.: popliteal artery

v. s. e.: ext. saphenous vein.
n. t.: int. popliteal nerve.
n. p.: ext. popliteal nerve.
b. p.: praepatellar bursa.

Fig. 522.



Stump after disarticulation at the knee by the circular method.

Fig. 523.

Stump after disarticulation of the knee by the circular method with extirpation o. the patella.

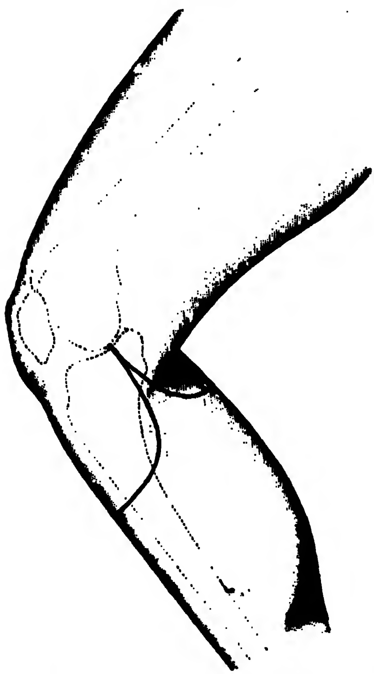
the middle of one condyle, and terminates $^1/_2$ inch below the middle of the other condyle, and this flap is dissected from the fascia up to its base.

2. The limb is lowered, flexed at the knee, and a larger flap of skin, 4 to 5 inches long, is outlined on the anterior surface between the same points. This flap is dissected up to the lower edge of the patella, and turned upwards (Fig. 524).

3. The separation of the articular ends of the bones is effected in the same way as in the circular method.

Fig. 525 shows the appearance of the stump.

Fig. 524.



Disarticulation at the knee by antero-posterior flaps.

Fig. 525.

Stump after disarticulation at the knee by the flap method.

4. If skin is wanting to make sufficiently large flaps, or if the lower surface of the condyles of the femur is diseased or injured, a piece can be sawed from the condyles of the femur — Carden's amputation through the condyles. The sharp angles of the sawed surface must be rounded off afterwards with the saw or the bone cutting forceps. Or the bone can be cut in the first place with a narrow saw in a curve parallel to the articular surface of the condyles (Butcher).

If the patella is healthy, it can be made to unite with the sawed surface of the condyles, and the stump thus made longer (Gritti's osteoplastic lengthening of the femur). To accomplish this, the cartilaginous surface of the patella must be sawed off and the latter securely nailed to the sawed surface of the condyles after the wound has been closed.

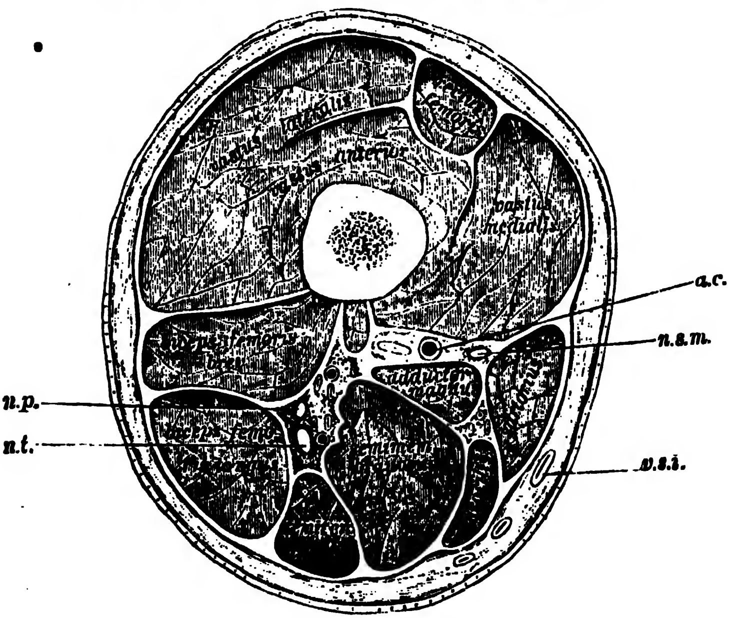
The following methods are suitable for **amputation of the thigh:**

The circular method of Celsus
(see page 217).

Method by circular skin-flap
(see page 219).

The modified flap method
(see page 221).

Fig. 526.
Transverse section of the right thigh in its lowest third.

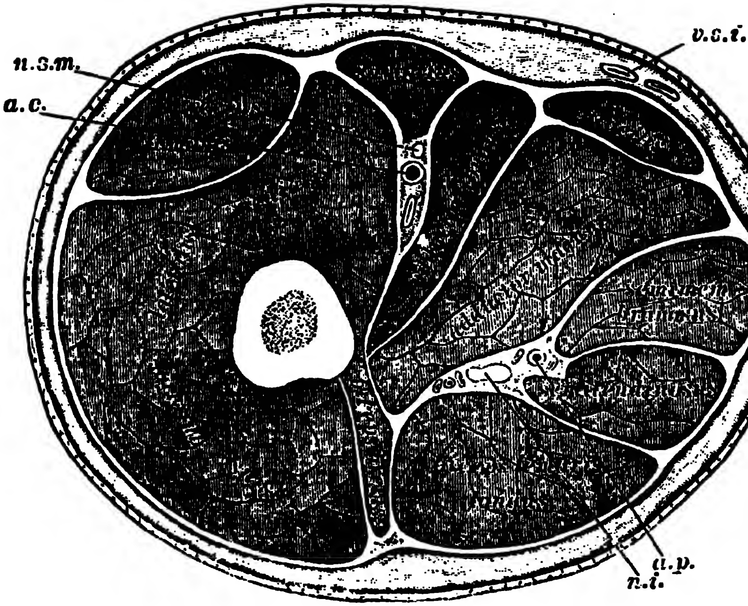


n. p.: ext. popliteal nerve.
n. t.: int. popliteal nerve.
v. s. i.: int. saphenous vein.
n. s. m.: int. saphenous nerve.
a. c.: femoral artery.

NB. In the figure, biceps femoris longus and brevis = long and short heads of biceps; vastus medialis and lateralis = internal and external vastus.

Fig. 527.

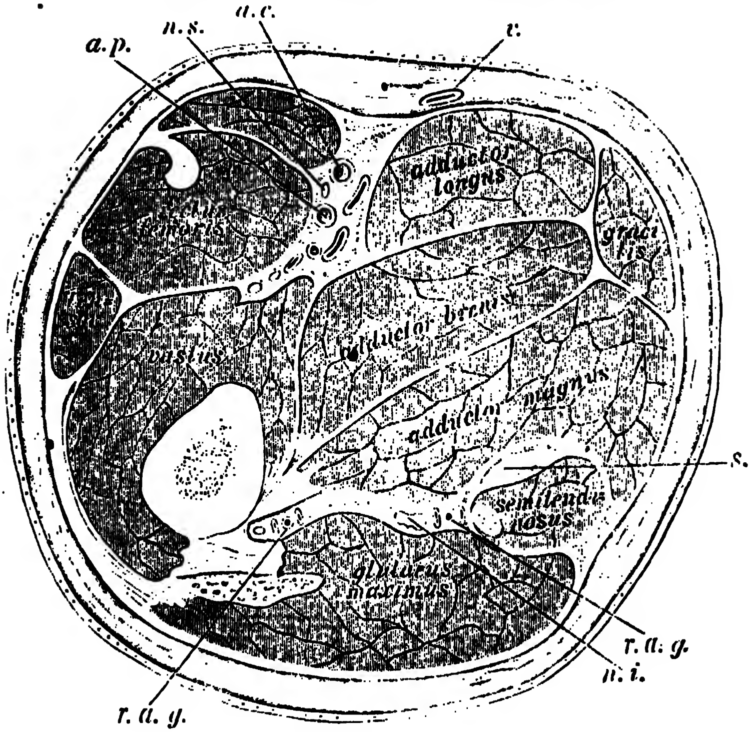
Transverse section of the right thigh in its middle third.



n. s. m.: int. saphenous nerv
a. c.: femoral artery.
n. i.: sciatic nerve
a. p.: profunda artery.
v. s. i.: saphenous vein.

Fig. 528.

Transverse section of the right thigh in its uppermost third.



a. c.: femoral artery.
n. s.: int. saphenous nerve.
a. p.: profunda artery.
n. i.: sciatic nerve.
s.: semi-membranosus.
v.: int. saphenous vein.
r. a. g.: branches of the sciatic artery.

Fig. 425 shows a completed antiseptic cushion dressing after amputation of the thigh, as described on page 27.

Volkmann's method for the application and renewal of the dressing after amputation of the thigh, is to be recommended.

The patient is lifted up and a block of wood, or a hard cushion of cubical shape, covered with rubber, is put under the buttock of the sound side, so that the amputation stump swings free, and does not need to be held during the application of the dressing. This also leaves the region of the back so free, that the turns of the spica bandage of the thigh which holds the dressing in place, can be easily passed around the body (Fig. 529).

Fig. 529.

Position of the patient during the application of the dressing.

q. DISARTICULATION OF THE THIGH.

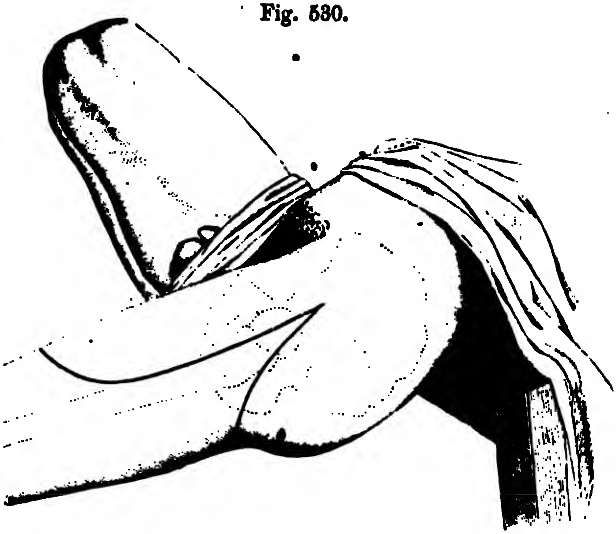
1. WITH A LARGE ANTERIOR AND A SMALL POSTERIOR FLAP, ACCORDING TO MANEC (METHOD BY TRANSFIXION).

1. The patient is so placed that the half of the pelvis on the injured side projects over the edge of the table. The upper part of the body must be well secured, and the scrotum drawn upwards, and towards the sound side (Fig. 530).

2. After the limb has been made bloodless in the manner described on page 175, a large anterior flap is cut from within outwards as follows: — The operator thrusts a long pointed amputation knife (see Fig. 398) into the limb, parallel with Poupart's ligament, entering it at a point halfway between the anterior superior spine of the ilium and the apex of the trochanter, and cautiously grazing the head of the femur (the capsule of the femur being opened in so doing); he then turns the point of the knife downwards and inwards, and brings it out on the inner side of the thigh near the perineum (Fig. 531). Carrying the knife downwards with quick sawing strokes, he cuts a well-rounded flap 7 to 8 inches long, which is immediately reflected above, and securely held there.

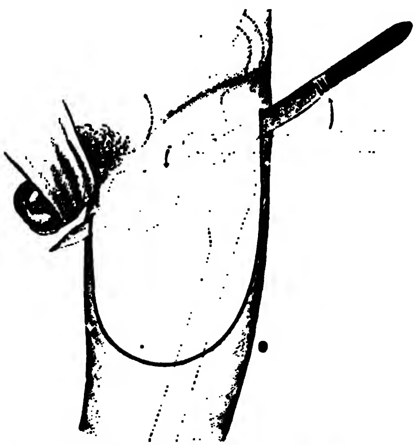
3. The knife is passed under the thigh to its inner side, and a small posterior flap cut from without inwards, its convexity extend-

Fig. 530.



Disarticulation at the thigh with antero-posterior flaps.

Fig. 531.



Formation of the anterior flap by transfixion.

ing below the gluteal fold, and its base meeting the base of the other flap on the inner and outer sides of the limb (Fig. 532).

4. A bold cut, made perpendicularly upon the exposed head of the femur with a small knife (as if the operator intended to cut through the head, and leave its upper part in the acetabulum), opens the capsule of the joint, the limb being at the same time strongly over-

extended, and rotated outwards. The air rushes into the articular cavity with a sucking sound, the head of the femur comes half out of the acetabulum, and a cut through the ligamentum teres allows it to escape entirely.

Fig. 532.

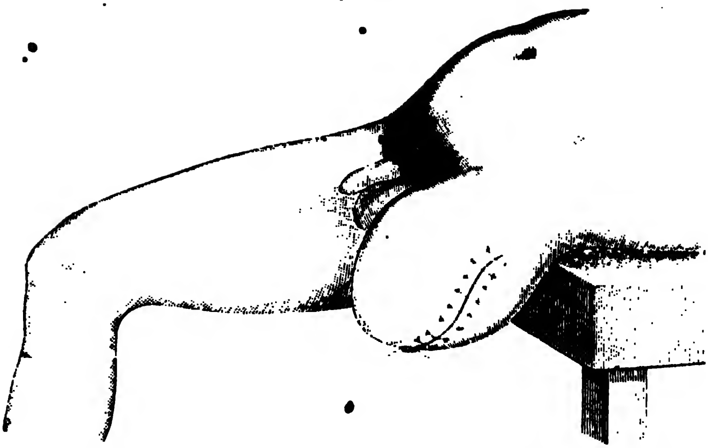
5. The operator seizes the head of the femur with his left hand, draws it towards him, and cuts through the posterior part of the capsule, the muscles attached to the great trochanter, and all the soft parts which still remain undivided.

6. One end of a large drainage tube is placed in the acetabulum, and the other brought out of the middle of the wound, and the anterior flap turned down and united with the posterior edge of the wound, as is shown in Fig. 533.

2. DISARTICULATION AT THE HIP BY THE CIRCULAR METHOD (Vetch).

1. All the soft parts are cut through to the bone by a bold circular cut, 5 inches below the apex of the great trochanter; then the bone is immediately sawed off at that point.

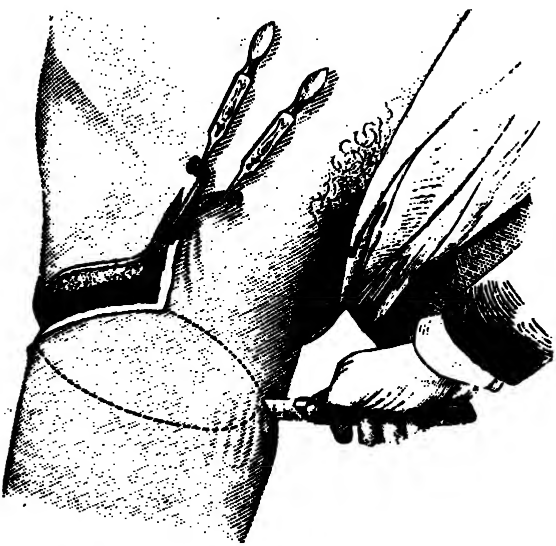
Fig. 533.



Stump after disarticulation at the hip with antero-posterior flaps.

2. All the vessels which can be recognized, both arteries and veins, are seized with clamp-forceps and ligated with catgut (see the transverse section of the thigh in its uppermost third — Fig. 528).

Fig. 534.



Disarticulation at the hip by the circular method.

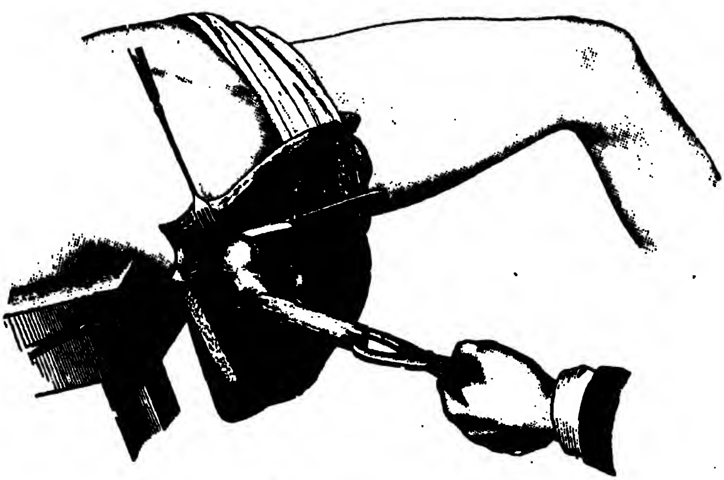
3. In cases in which the bloodless method cannot be employed, it is advisable to expose the artery and vein by a longitudinal incision in Scarpa's triangle before the circular incision is made (according to Larrey). When this is done, the vessels are secured with two clamp forceps and divided between them, the distal ends then being ligated, and the central ends held above until the operation is completed (Fig. 534).

4. If all hemorrhage is arrested after removal of the constricting band, an amputation knife is thrust down to the head of the femur, entering 2 inches above the apex of the great trochanter, and thence carried downwards along the middle of the trochanter to the circular incision, dividing the soft parts, and penetrating to the bone in its entire length (Dieffenbach).

5. The operator seizes the lower end of the stump of the bone with a strong bone forceps, and, while the edges of the vertical incision are drawn apart by assistants, detaches the periosteum from the bone on every side with the raspatorium. until he reaches the stronger attachments of the muscles, which will have to be separated from the bone by short cuts with a stout knife.

6. When the bone has been dissected free in this way, up to the capsular ligament, the latter is opened as has been described above, and the head of the femur freed (Fig. 535). The hemorrhage is usually slight in this part of the operation.

Fig. 535.



Disarticulation at the hip.

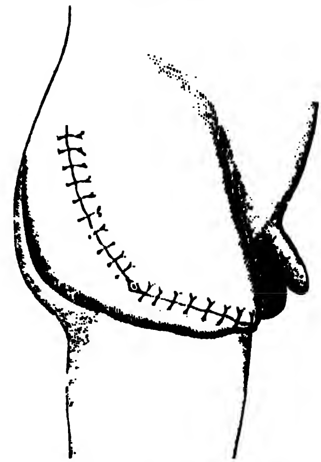
Fig. 536 shows the appearance of the stump.

7. If the muscles are very massive, instead of the circular method according to Celsus, the ordinary circular skin-flap method can be em-

ployed; or a large anterior flap of skin can be formed, and the soft parts divided by a circular cut just below the gluteal fold.

8. If there are not enough soft parts in front, a large flap can also be made posteriorly (von Langenbeck), and a transverse incision made in front, below Poupart's ligament. In this case, however, it is necessary to introduce a large drainage tube as far up as the stumps of the psoas and iliacus muscles, which retract into the pelvic cavity, so that discharges may not collect there.

Fig. 536.



Stump after disarticulation at the hip by the circular method.

r. REAMPUTATION.

1. If not enough soft parts have been spared in an amputation, or if they have retracted during the healing of the wound in consequence of inflammatory swelling (ostitis), or if they have been destroyed by gangrene, the so-called **conical stump** (Fig. 537) is formed — that is, the end of the bone projects so that complete healing is impossible (ulcus prominens), or the thin cicatrix which has finally formed breaks down again as soon as the patient uses an artificial leg. Stumps which remain after a limb has been destroyed by frostbite, or a burn, are usually of this kind.

Fig. 537.

Conical stump.

2. In such cases it was formerly the custom to amputate again at a higher level, or to attempt to cover the scar by the transplantation of flaps of skin. But the former is generally unnecessary, and is just as dangerous to life as the first amputation, while the latter but seldom gives a satisfactory result, because the skin of the extremities is not well suited to plastic operations.

3. It is much better to make a **subperiosteal resection of the stump of the bone** — that is, to cut around the scar or ulcerated surface of the projecting end of bone, divide the soft parts of the stump vertically, or laterally (avoiding the regions where the large vascular and nervous trunks lie), down to the bone, and to detach the

periosteum far enough to allow of the removal of a sufficiently large piece of bone with the small saw, or the chain-saw. The hemorrhage is generally slight. The wound is united by deep and superficial sutures, after introducing a drainage tube as far as the sawn surface. It generally heals by first intention, and the result is a good stump completely covered with soft parts.

4. If the first amputation has been near a joint, a **subperiosteal disarticulation** can be subsequently performed in a similar manner (Compare Fig. 535).

THE INDICATIONS FOR OPERATIVE MEASURES AFTER INJURIES OF THE LARGE JOINTS.

Although the indications for amputations in general have already been discussed (page 157), I consider it necessary to give here the indications which can be laid down for the injuries of the individual joints, now that the antiseptic treatment of wounds in general has been introduced.

INJURIES OF THE WRIST.

1. In extensive laceration and shattering of the hand, involving the wrist, **primary amputation of the forearm,** or **disarticulation at the wrist** is indicated.

2. In gunshot fractures of the **epiphysis of the radius, the ulna, and the carpal bones,** as well as in **comminution of the carpus** alone, if the spent ball **remains** in the parts, **primary resection** is indicated.

3. In **stab-** and **incised wounds, glancing wounds,** or **simple penetration** of the wrist or carpus by a ball in full force, **conservative treatment** (antisepsis, elevation, fixation) is to be attempted.

4. If progressive purulent infiltration occurs, the joint must be **freely opened** and **drained.**

5. If the suppuration continues, **secondary total resection of the wrist** is indicated, if the extension of the septic process between the muscles of the forearm is not accompanied with such threatening symptoms (septicaemic or pyaemic) that only an amputation above the elbow can be taken into consideration.

6. The object of treatment is to preserve the **motions and utility of the hand.** To accomplish this, **complete resection is generally necessary,** but the removal of the carpal bones alone will sometimes suffice. The lower end of the ulna alone can also be resected, if the radio-carpal joint is not involved. Resections of the radius alone do not give good results.

INJURIES OF THE ELBOW.

1. **Primary resection,** or **amputation of the arm** (or disarticulation at the elbow) is only indicated when the brachial artery has been injured, as well as the articular ends, by small projectiles or incised wounds, or when the forearm has been torn off up to the elbow, or hopelessly shattered by a large shot.

2. In extensive gun-shot fractures of the elbow, **primary resection** is indicated.

3. If there is no opportunity to resect, it is advisable to employ conservative antiseptic treatment, until the period of progressive inflammatory infiltration has passed.

4. In simple injury of the capsule of the joint, by stab- or incised wounds, or a contusing projectile, **conservative treatment** must be attempted (antisepsis, fixation in a position of flexion to a right angle).

5. If suppuration of the joint begins, **secondary resection** must be performed, but not in the period of inflammatory infiltration. The dangers of the latter are rather to be met by free opening of the joint, drainage, and antiseptic irrigation, until the inflammation has reached its limits, and healthy suppuration has begun.

6. The object of treatment is to obtain a **movable** joint, or, if this is impossible, ankylosis with flexion to a right angle — not a flail-joint.

7. Therefore, if the lower end of the humerus alone is injured, and it is so shattered that it becomes necessary to remove a considerable portion of it, the ulna and radius should be left untouched. Similarly, nothing should be taken from the condyles of the humerus, when the upper ends of the bones of the forearm are extensively injured (**partial resection**).

INJURIES OF THE SHOULDER.

1. If the arm has been torn off close to the shoulder, or is irremediably shattered by a heavy shot, or if not only the shoulder-joint, but also the large vascular trunks of the axilla have been injured by smaller projectiles, **disarticulation of the upper extremity** is indicated.

2. In all gunshot fractures of the upper end of the humerus which are at all extensive, **primary resection** of the shoulder is indicated. If the comminution of the parts of the joint affects only the scapula, **resection** confined to that bone alone will be sufficient.

3. Even in cases in which the joint has been shattered, and the soft parts on its outer side greatly lacerated by a heavy shot, the limb can often be saved by **resection.**

4. **In less severe injuries of the shoulder-joint** (opening of the capsule by stab-, incised, or gunshot wounds, contusion of the head

of the humerus by a shot) **conservative treatment** (antisepsis, fixation) can be given a trial.

5. If suppuration begins in the joint in spite of this treatment, **secondary subperiosteal resection** is indicated, for the object of treatment is to preserve a **movable** shoulder-joint, without allowing the humerus to be too far displaced from the articular surface of the scapula (flail-joint).

6. If ankylosis of the joint follows an injury to the shoulder, the utility of the arm can be improved by **secondary subperiosteal resection.**

INJURIES OF THE ANKLE.

1. In extensive shattering of the foot, and of the region of the ankle, by heavy shot, **primary amputation** of the **leg,** or **disarticulation at the ankle,** or **through the tarsus,** is indicated.

2. In cases of considerable comminution of the articular ends of both bones of the leg, and of the tarsus, by smaller shot, **primary resection** of the ankle is indicated.

3. In **less severe injuries** of the joint, (simple wounds of the capsule by stabs, cuts, or gunshot; perforating gunshot wounds of the malleoli, or of the astragalus alone; limited comminution of one malleolus, or of the astragalus alone) **conservative treatment** is to be attempted. (In recent cases, antiseptic occlusive dressing with fixation of the foot at right angles to the leg, and elevation; if inflammation and suppuration have already set in, provision for the escape of the pus, and relief of pressure, by timely free incisions, drainage, and antiseptic irrigation).

4. Even when a fragment of a shell has extensively opened the ankle joint, but without greatly contusing other parts, conservative treatment can be tried.

5. In **suppuration of the ankle-joint** with threatening fever, **secondary resection** is indicated; and indeed, if all three bones are injured, **total resection** (of both epiphyses and of the upper articular surface of the astragalus); if the tibia or the astragalus alone is injured, only these two bones will require resection; but if the external malleolus is injured, both it and the upper surface of the astragalus must be resected, in order to secure free outlet to the pus.

6. As it is desirable to obtain either a movable joint, or ankylosis of the joint at a right angle, with as little shortening as possible, no more should be removed from the bone than is absolutely necessary. In many cases it will suffice merely to cut away both malleoli, with the gouge, or to bore smooth cylindrical openings in both malleoli and to introduce short drainage tubes into the cavity of the articulation. If the tendo Achillis has been penetrated by the ball, and the joint in-

jured posteriorly, a transverse incision in the capsule at the back will suffice.

INJURIES OF THE KNEE-JOINT.

1. In gunshot fractures of the articular ends, with considerable laceration of the soft parts, or with injury of the great vessels in the popliteal space, and when the entire leg has been shattered by heavy shot, **primary amputation of the thigh,** or perhaps **disarticulation** at the knee, is indicated.

2. In all other gunshot injuries of the knee-joint, antiseptic occlusion with fixation should first be tried.

3. If, in spite of this treatment, suppuration occurs, with high fever, there should be no delay in at once undertaking the antiseptic incision and **drainage** of the joint, and at the same time all fragments of bone which are entirely isolated, and all foreign bodies, must be removed.

4. If threatening suppuration still continues, or the drainage of the joint seems insufficient, the **typical resection** must be undertaken.

5. Only in extreme necessity, when the sepsis of the joint and the surrounding parts has gone so far that preservation of the limb seems no longer possible, should **secondary amputation** of the thigh be performed, in the attempt to save the patient's life.

6. The attainment of **ankylosis** of the joint in extension, with the least possible shortening, is the aim of resection.

INJURIES OF THE HIP-JOINT.

1. In **very severe gunshot fractures of the hip-joint** (extensive comminution of the upper end of the femur with great laceration of the soft parts), in injuries of the joint **with laceration of the large vessels,** or with simultaneous severe injury of the knee-joint, and when the entire limb has been torn off, with splintering of the bone extending into the joint, **primary disarticulation** at the hip is indicated.

2. In all other injuries of the hip which must evidently be followed by **suppuration** of the joint (comminution of the head or neck of the femur, or the acetabulum, separation of the head) **primary resection of the hip** is indicated.

3. If the proposed disarticulation is refused by the patient, or if there is no opportunity to perform that operation or a resection before the inflammatory reaction has set in, the dangers of sepsis are to be combatted with fixation, extension, antisepsis, drainage, and ice, until suppuration is established. Transportation of the wounded for great distances, and by unsuitable means, is to be avoided as far as possible.

4. In **less severe** injuries of the joint (a wound grazing the capsule, the head of the femur, or the acetabulum) with insignificant symptoms at first — as, for instance, when the injured man can still walk, **conservative treatment** by antiseptic occlusion can be attempted.

5. But if **suppuration** of the hip-joint makes its appearance, **secondary resection** must be performed.

6. The object of resection should be to obtain a **movable joint**, in a position of as great extension as possible, and in abduction.

RESECTION OF THE JOINTS.

GENERAL DIRECTIONS FOR RESECTIONS.

1. The object of resection is to remove the injured or diseased articular ends, with the least possible injury to the soft parts.

2. The **incisions** in the skin and muscles should therefore lie by preference in the **long axis** of the limb, and every injury of the larger vessels, nerves, and tendons must be carefully avoided.

3. The **preservation of the periosteum** in connection with all the tendons and muscles attached to it in the neighborhood of the joint (**subperiosteal resection** — von Langenbeck, Ollier) is of the greatest importance — both for the course of healing in the wound, and for the ultimate functional powers of the limb, and should therefore be always attempted. The operation is by this method rendered more difficult in the primary cases, and easier in the later cases. For this reason the older method (not subperiosteal) will also be described when dealing with the resection of the individual joints.

Fig. 538.

Raspatory.

Fig. 539.

Fig. 540.

Narrow and broad elevators of von Langenbeck.

Fig. 541.

Bent elevator.

4. In order to preserve the periosteum, it must be divided in the line of the incision in the skin, and, together with the other soft parts, raised from the bone by blunt instruments, the raspatory (Fig. 538) and elevator (Figs. 539 to 542).

5. The fibrous capsule of the joint, the ligaments, and the insertions of the muscles can not be separated from the bone by blunt instruments, but must be dissected up by knives with short strong blades (Fig. 543), the knife being held perpendicular to the bone, and the tissues must always be left attached to the neighboring periosteum.

6. Therefore, in performing this part of the operation, the knife and the elevator must be intelligently alternated, and the greatest care taken not to contuse or lacerate the periosteum.

Fig. 542.

Sayre's elevator.

Fig. 543.

Resection knife.

In some cases the labor can be lightened by cutting off the external surface of the bony projections (tubercles, malleoli, condyles, trochanters) to which the muscles and ligaments are attached, with hammer and chisel (according to Vogt).

7. After the articular ends have been stripped of periosteum, they are made to project through the wound, seized with powerful forceps (Figs. 544 to 546) and removed with a saw (Figs. 547 to 552). Meanwhile the soft parts are retracted and protected by blunt hooks (Figs. 297 and 298), or sharp hooks (Figs. 296 and 299), or by a strip of leather or brass (Figs. 560 and 607).

8. If one of the articular ends has been shot away, it may be seized with von Langenbeck's bone hook (Fig. 553), and drawn out. If it has been broken into several fragments, each piece is to be seized with forceps and dissected out, unless it is desired to attempt to make them unite in their proper places.

9. Since the regeneration of a joint is generally most complete when only one articular end is removed, it is advisable, if the injury to one articular end is very extensive, only to resect this, and to leave the other intact (partial resection). This is particularly true of the upper extremity.

10. Most resections can be performed with greater advantage by the aid of the bloodless method. After the operation has been completed, however, all the injured vessels must be carefully ligated before the wound is closed, for otherwise secondary hemorrhage is apt to follow, and this may make it necessary to remove the dressing, and

Fig. 544.

von Langenbeck's bone forceps.

Fig. 545.

Fergusson's lion-tooth forceps.

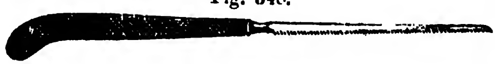
Fig. 546.

Faraboeuf's bone forceps.

Fig. 547.

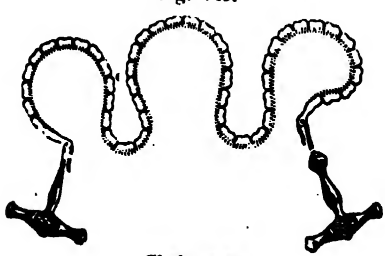
Small saw.

Fig. 548.



von Langenbeck's keyhole saw.

Fig. 549.

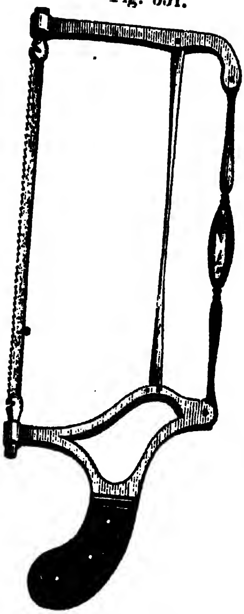


Chain saw.

Fig. 550.

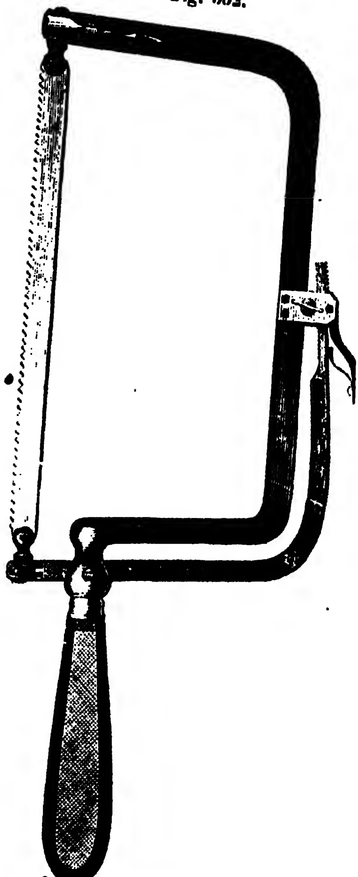
Small saw.

Fig. 551.



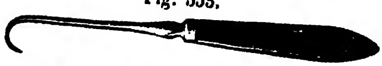
Butcher's resection saw.

Fig. 552.



Szymanowsky's resection saw.

Fig. 553.



von Langenbeck's bone hook.

disturb the wound again. For the dressing after resection see page 158.

11. If the healing of the wound after resection, instead of making rapid progress, entirely or chiefly by first intention, is completed slowly and after prolonged suppuration, the long continued fixa-

tion may cause the ligaments and tendons to shrink and form adhesions, the joints of the limb to grow stiff, and the muscles weak and atrophic (**paralysis of disuse**).

To the inexperienced, the whole limb then appears to have become useless, and in fact it will remain in this worthless condition if nothing is done to relieve it.

12. To avoid this condition, or to relieve it, **methodical passive motion** must be undertaken in all the joints of the extremity, immediately after the cicatrization of the wound. If there is great pain at first, chloroform anaesthesia should be employed (**apolyse** according to Neudorfer).

13. The joints of the upper extremity, especially the fingers, in which it is desirable to have motion very early, can be kept movable from the beginning, by cautious movements, such as giving them a different position every time the dressing is renewed.

14. The functions of the **muscles** and **nerves** can be restored by **warm baths** and the use of **electricity**. Methodical **kneading** of the limbs (**massage**), preceded by a **cold douche**, and followed by **gymnastic exercises**, is generally still more efficacious for this purpose.

15. If too great mobility and relaxation of the resected joint (**flail-joint**) is the result of the operation, it can be lessened by a supporting apparatus.

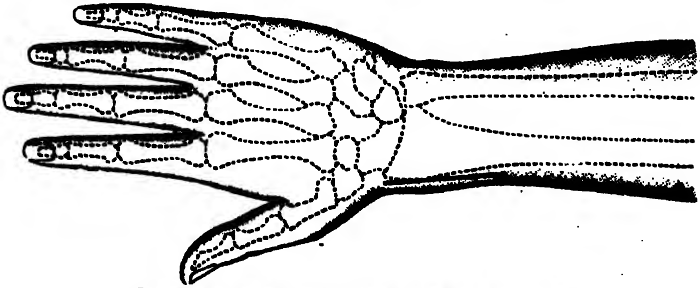
RESECTION OF THE INFERIOR ARTICULAR ENDS OF THE RADIUS AND ULNA.

With bilateral incision.

1. A longitudinal incision, beginning below the styloid process of the ulna, is carried through the skin for about 2 inches upwards, along the internal surface of the ulna (Fig. 554).

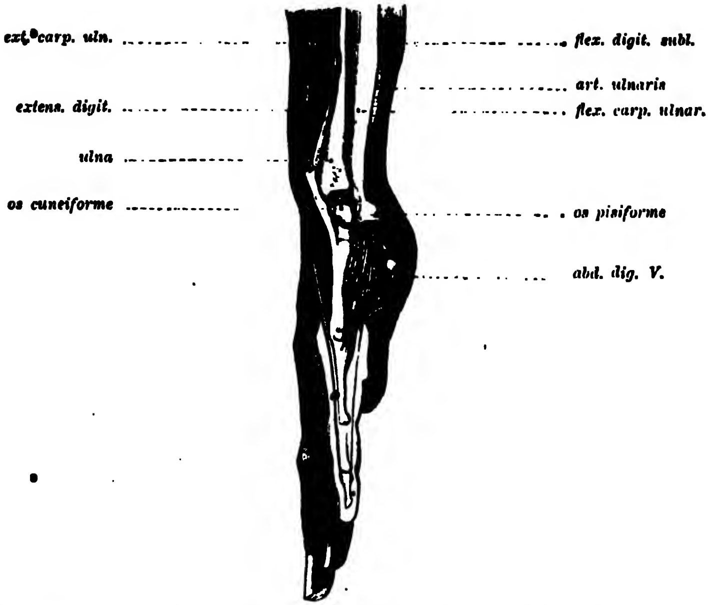
2. The periosteum is divided exactly in the same line, between the extensor and flexor carpi ulnaris muscles, and raised from the bone

Fig. 554.



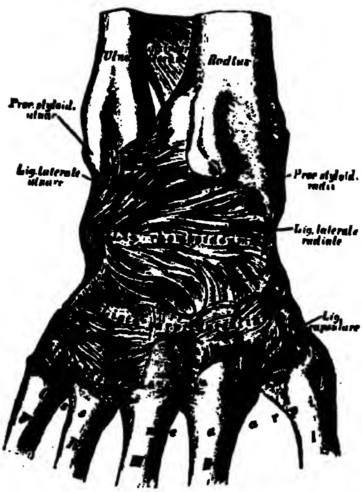
Resection of the radius and ulna at the wrist.
Bilateral incision according to Bourgery.

Fig. 555.



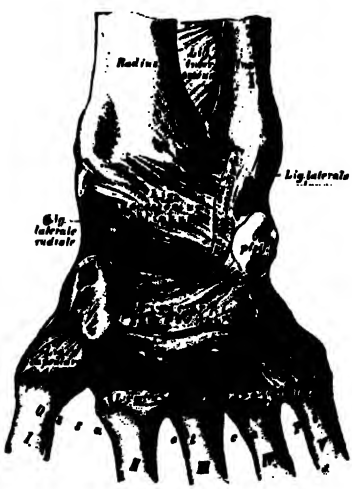
Muscles and tendons on the ulnar side of the left wrist (according to Henke).

Fig. 556.



Dorsum.

Fig. 557.



Palm.

Ligaments of the right wrist.

with raspatory and elevator, on the posterior surface first, and then on the anterior surface (pronator quadratus) as far as the interosseous ligament (Fig. 555).

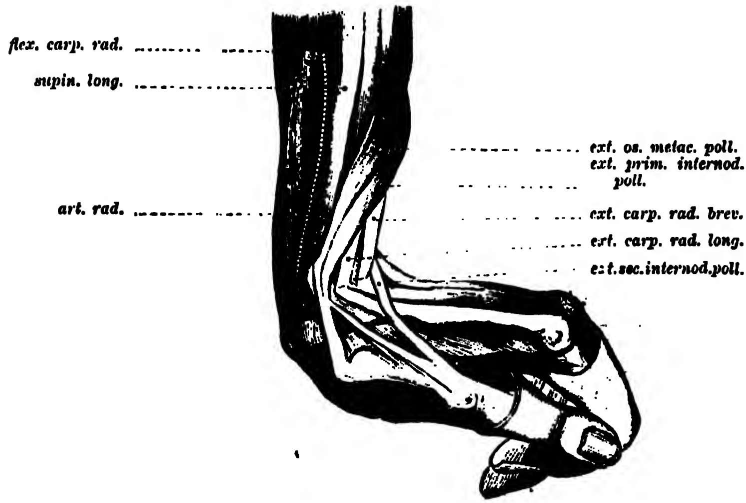
3. The part of the ulna which is thus laid bare, is sawed off with the keyhole saw, or cut off with a strong bone-cutting forceps, below the upper angle of the wound.

4. This piece, when sawed off, is seized with the bone forceps, twisted around, and removed after cutting the interosseous ligament, the lateral ulnar ligament, and the anterior ligament of the wrist (Fig. 556 and 557).

5. A second longitudinal incision, beginning below the styloid process of the radius, divides the skin for 2 to $2^1/_2$ inches upwards, along the external surface of the radius.

6. The tendons of the extensor ossis metacarpi and primi internodii pollicis, which cross the radius obliquely, are drawn aside while the hand is bent far backwards (Fig. 558).

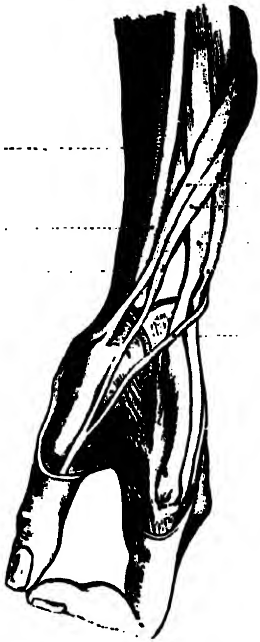
Fig. 558.



Muscles and tendons of the radial side of the left wrist, the hand bent backwards (according to Henke).

7. The tendon of the supinator longus (Fig. 559) is cut from the styloid process of the radius, the periosteum of the radius is divided longitudinally, and is raised from the bone, together with the sheaths of all the tendons, by raspatory, elevator, and knife, first on the posterior, and then on the anterior surface (pronator quadratus), until the soft parts can be retracted, and the bare bone exposed on all sides, for a distance of $1^1/_2$ inch above the joint surface.

Fig. 559.



Muscles and tendons of the radial side of the left wrist, in extension (according to Henke).

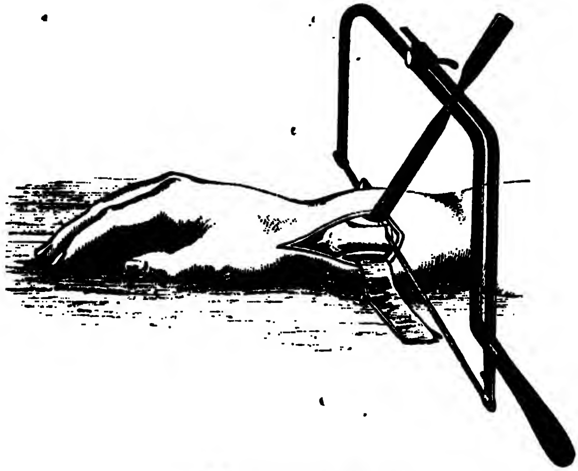
In primary resection, the periosteum is so adherent to the bone that it is very difficult to separate it, while maintaining its connection with the tendon sheaths, and without injuring the latter.

In this case it is advisable (according to Vogt) to separate a thin layer of bone, together with the periosteum, with a sharp chisel, first from the posterior, and then from the anterior surface of the radius, and finally from the styloid process, under the extensor ossis metacarpi pollicis.

8. A wide strip of brass is passed through on the anterior side, between the bone and the periosteum, to protect the soft parts, and while the periosteum and the soft parts of the posterior side are drawn upwards with a similar strip or a blunt hook, the lower end of the radius is sawed off with a keyhole saw or a small resection saw (Fig. 560).

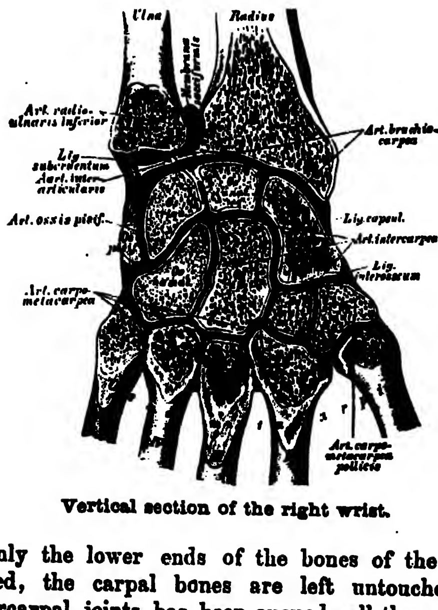
9. The piece sawed off is seized with the bone forceps, drawn out of the wound, and separated from the carpal bones by division of the capsule and ligaments of the joint — external lateral, anterior, and posterior ligaments (Figs. 556 and 557) —.

Fig. 560.



Sawing off the radius.

Fig. 561.



Vertical section of the right wrist.

10. If only the lower ends of the bones of the forearm are injured or diseased, the carpal bones are left untouched. But if even one of the intercarpal joints has been opened, all the carpal bones (with perhaps the exception of the trapezium and the pisiform) must be re-

moved, for all the joints between the individual carpal bones, and between them and the metacarpal bones, communicate with one another (Fig. 561). In this case complete resection of the wrist should be performed.

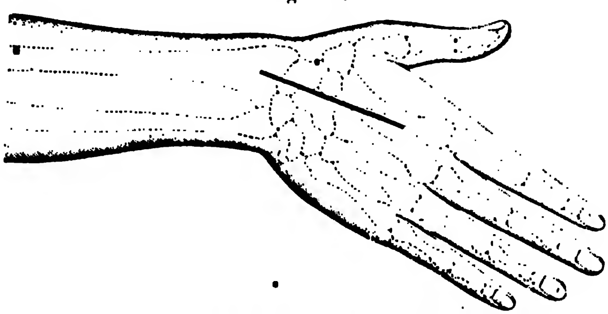
COMPLETE RESECTION OF THE WRIST.

With the dorso-radial incision of von Langenbeck.

1. The operator should be **seated** at a small table, upon which the hand is laid palm downwards, and slightly drawn towards the ulnar side. An assistant sits opposite to him.

2. An incision, beginning at the middle of the internal border of the os metacarpi indicis, divides the skin, passing upwards for 4 inches, to a point on the middle of the posterior surface of the radius above the epiphysis (Fig. 562).

Fig. 562.



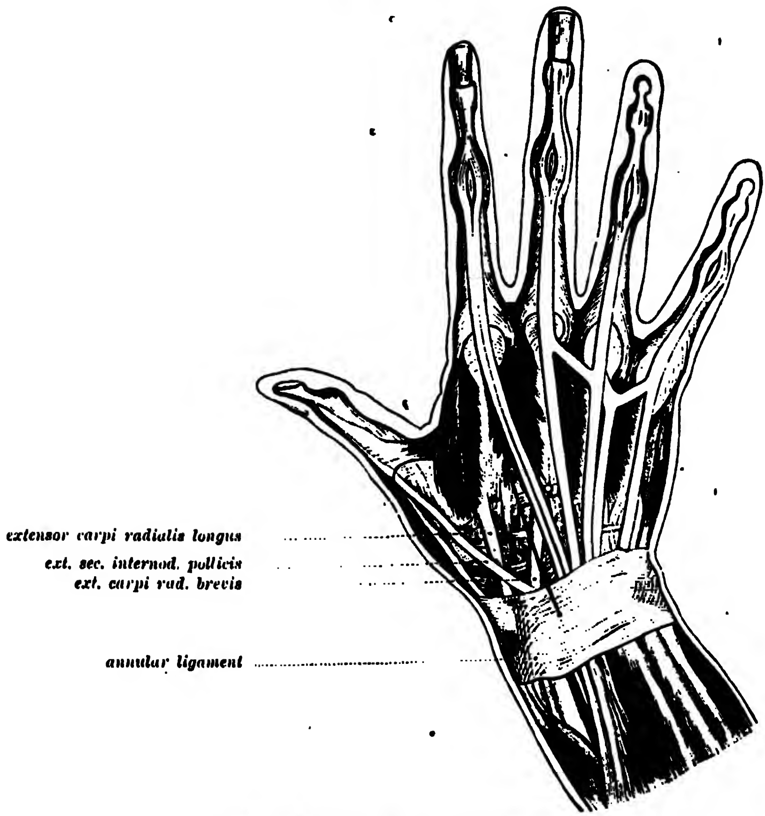
Resection of the wrist according to von Langenbeck.

3. The incision is carried along the outer side of the extensor tendon of the index finger, and without injuring its sheath; higher up it passes along the internal edge of the extensor carpi radialis (where its tendon is inserted into the base of the third metacarpal bone), and divides the annular ligament just between the tendons of the extensor secundi internodii pollicis and the extensor indicis, as high as the upper border of the epiphysis of the radius (Fig. 563).

4. While an assistant draws the soft parts aside with small retractors, the capsule of the joint is incised longitudinally, and then, together with the ligaments, it is separated from the bone as follows: —

5. First the fibrous sheaths which contain the tendons of the extensor secundi internodii pollicis, and of the extensor carpi radialis longus and brevis, where they run in grooves in the radius, and the tendon of the supinator longus, must be detached from the bone on the outer side of the incision, partly with the knife, partly with the elevators

Fig. 563.



Tendons of the back of the hand.

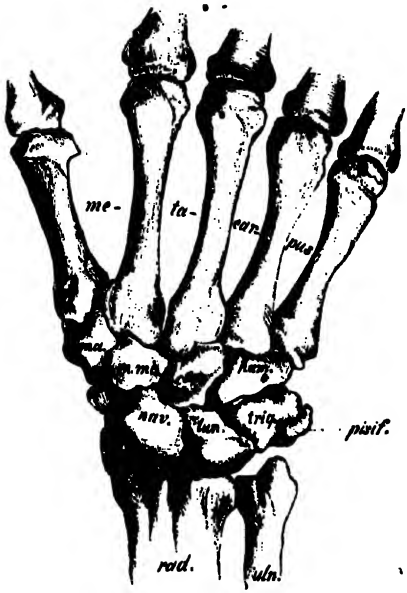
6. Next, on the inner side, the tendons of the extensors of the fingers, and the fibres of the annular ligament which surround them, are to be separated from the bone in the same way, together with the periosteum and the capsule of the joint, and drawn inwards.

7. The radio-carpal articulation then lies open. The hand is flexed so that the joint surfaces of the upper row of carpal bones appear.

8. By division of the intercarpal ligaments, the scaphoid bone is separated from the trapezium and the trapezoid; and the semi-lunar and cuneiform, from the os magnum and unciform; they are gently extracted with a narrow elevator. The trapezium and pisiform may be allowed to remain (Fig. 564).

9. Next the bones of the lower row are removed. The rounded articular surface of the os magnum is seized with the fingers of the left hand, or with a dressing forceps, and, while an assistant abducts

Fig. 564.



The bones of the carpus.

the thumb, the ligamentous connections between the trapezoid and the trapezium are divided. Then the knife is made to penetrate, on the inner side of the joint, into the carpo-metacarpal articulations, by cutting through the ligaments on the extensor side of the upper end of the metacarpal bones, while an assistant strongly flexes the latter. The three bones of the lower carpal row (trapezoid, os magnum, and unciform) can thus be extracted together.

10. Finally, the epiphyses of the radius and ulna are thrust out of the wound by strong flexion of the hand, carefully bared of periosteum as has been previously described, and sawed off. In sawing the bones, care must be taken not to injure the large dorsal branch of the radial artery, which passes across the trapezium to the interval between the metacarpal bones of the thumb and index finger (Fig. 559).

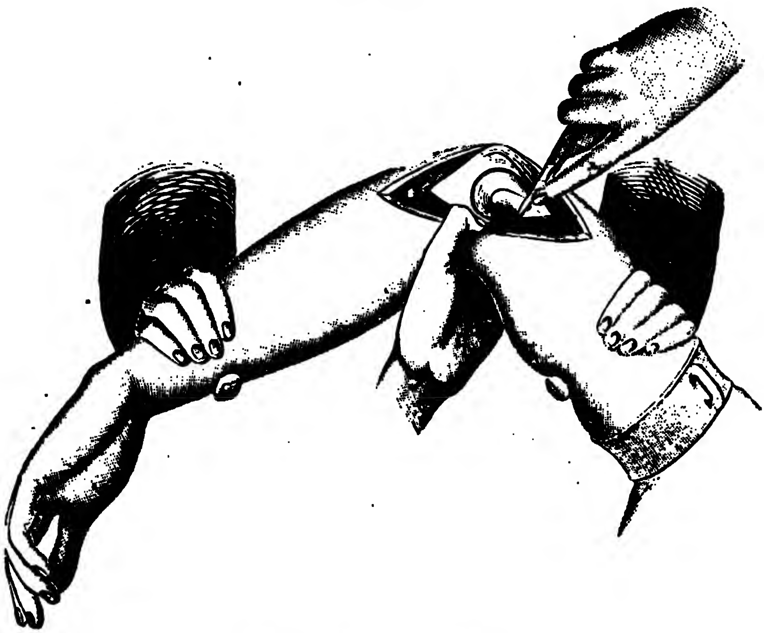
11. After the operation is completed, and the antiseptic dressing applied, the limb must be securely fixed upon one of the splints shown in figures 135, 293, 196 to 200, 204, and 205. Extension (see page 123), and passive motion of the joints of the fingers, must be begun as soon as possible.

RESECTION OF THE ELBOW ACCORDING TO LISTON.

With the T-incision.

1. The posterior surface of the elbow, bent at an obtuse angle, is held in front of the operator, by an assistant who seizes the forearm with one hand, and the arm with the other (Fig. 565).

Fig. 565.

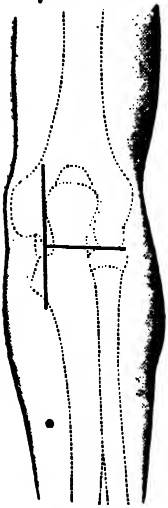


Resection of the left elbow joint.
Detaching the periosteum from the internal condyle.

2. A longitudinal incision, about 3 inches in length, the middle portion of which lies along the internal edge of the olecranon, opens the capsule of the joint, between the olecranon and the internal condyle (Fig. 566).

3. While the left thumb nail draws the soft parts covering the internal condyle strongly inwards, a short knife separates them completely from the bone, with cuts directed perpendicularly to the latter, until the epicondyle is exposed in the wound (Fig. 565). During this part of the operation, the forearm must be flexed more and more strongly by the assistant. The ulnar nerve lies in the middle of the soft parts thus dissected off, and does not come in sight (Fig. 567).

Fig. 566.



Resection of the right elbow.
T-incision according to Liston.

Fig. 567.

Ulnar nerve at the back of the left elbow.

4. By an incision carried in a semicircle below the internal condyle, the internal lateral ligament (*Fig.* 568) is divided, together with the attachment of the flexor muscles of the forearm.

5. The arm is extended again, and an incision is made directly across the olecranon, from the lower border of the external condyle to the middle of the first incision (see Fig. 565).

6. The periosteum is detached from the back of the ulna with the elevator, beginning at the internal border, and leaving it attached to the tendon of the triceps, which must be separated from the apex of the olecranon with the knife.

7. Both are then pushed outwards over the external condyle, the joint gapes, and a few cuts divide the annular ligament of the radius (between the head of that bone and the ulna), and the external lateral ligament (Fig. 569).

8. The joint is now freely open; the articular end of the humerus is seized with a bone forceps, and it is sawed off at the edge of the layer of hyaline cartilage.

Fig. 568.

Internal aspect.

Fig. 569.

External aspect.

Ligaments of the right elbow-joint.

9. The upper fibres of the brachialis anticus are divided by a cut directed against the point of the coronoid process of the ulna; the olecranon is seized with the forceps, and the articular end of the ulna, including all that is covered with cartilage, is sawed off.

10. The head of the radius is also sawed off.

11. After arresting the hemorrhage, the tendon of the triceps is sewed, by means of the periosteum attached to it, to the periosteum of the stump of the ulna, with some catgut sutures. The transverse incision is sutured, but the longitudinal incision is sewed only at its two ends, while through the middle a drainage tube is inserted in the cavity of the wound.

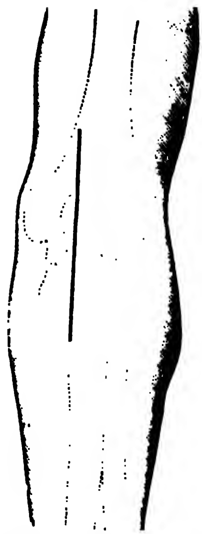
SUBPERIOSTEAL RESECTION OF THE ELBOW ACCORDING TO VON LANGENBECK.

With simple longitudinal incision.

1. An incision, 3 to 4 inches long, is made over the extensor surface of the joint just internal to the middle line of the olecranon, beginning $1^1/_2$ to 2 inches above the apex of the latter, and ending 2 to $2^1/_2$ inches below it, at the posterior border on the ulna. The incis-

ion in its entire length penetrates through muscle, tendon, and periosteum to the bone (Fig. 570).

Fig. 570.



Resection of the right elbow with von Langenbeck's incision.

2. The periosteum of the ulna is first detached on the inner side with raspatory and elevator, and the internal half of the tendon of the triceps is separated from the bone in connection with the periosteum, by short, parallel, longitudinal cuts with the knife — always directed against the bone.

3. The soft parts which cover the internal condyle and enclose the ulnar nerve, are drawn towards the point of the epicondyle with the left thumb nail, and detached from the bone by curved cuts, made close together, and directed against the bone, until the epicondyle is entirely exposed. The last incisions curve around the projecting bony point, and divide the attachment of the flexor muscles of the forearm, and at the same time the internal lateral ligament, but without separating these parts from the periosteum.

4. After the detached soft parts have been returned to their original position, the outer part of the tendon of the triceps is drawn outwards, and separated from the olecranon by short cuts, but left in connection with the periosteum of the outer side of the ulna, which raised from the bone together with the anconeus muscle.

5. By successive cuts with the knife, directed against the bone, the fibrous capsule of the joint is separated from the edges of the articular surface of the humerus (first from the trochlea, then from the radial head) until the external condyle comes in sight.

6. Then the external lateral ligament, and the attachment of the extensor muscles of the forearm, are separated from the condyle, so as to leave all these parts in connection with one another, and with the periosteum of the humerus.

7. When the external condyle has thus been laid bare, the joint is strongly flexed, the articular ends are made to protrude through the wound, and sawed off in succession as before described.

8. If it is desired to saw off the ulna below the coronoid process, the upper fibres of the tendon of the brachialis anticus must be cut away from it, without detaching the tendon from the periosteum of the ulna.

RESECTION OF THE ELBOW ACCORDING TO HÜTER.

With bilateral longitudinal incision.

1. A longitudinal incision, 1 inch in length, exposes the internal condyle; a curved incision, passing around its base, divides the internal lateral ligament.

2. Another longitudinal incision on the external side of the joint, 3 to 4 inches in length, passes over the external condyle and the head of the radius.

3. The soft parts are drawn apart, and the external lateral ligament is divided, together with the annular ligament of the radius.

4. The head of the radius is stripped of periosteum, and sawed off with the keyhole saw.

5. The attachments of the capsule to the humerus are separated in front and behind, first from the edge of the radial head, and afterwards from the trochlea.

6. The humerus is thrust out of the wound by drawing the forearm inwards, and as this is done the ulnar nerve slips from the posterior surface of the bone.

7. The articular end of the humerus is sawed off.

8. The olecranon is stripped of periosteum and sawed off.

AFTER-TREATMENT.

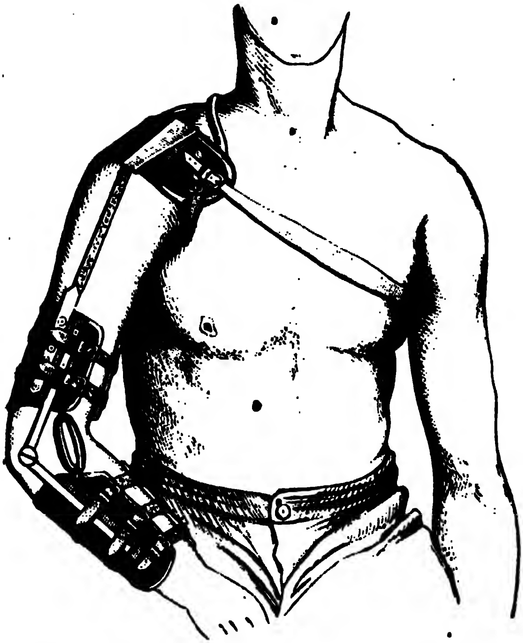
After the antiseptic dressing has been applied, the resected arm is first laid upon one of the splints shown in figures 133, 135, 149, and 283, and secured with gauze bandages.

The advice of Roser, to place the resected elbow in a position of extension at first, in order to avoid the development of a flail-joint, is excellent. In recent years, therefore, I have used for this purpose either the glass splint shown in Fig. 149, or a splint of similar shape made of wire.

But to avoid ankylosis in this position, as soon as the wound is healed, or nearly healed, the arm must be bent at the elbow, and treated with passive motion at every renewal of the dressing.

If a flail-joint develops after resection of the elbow, firmness and usefulness can be restored to the arm by the use of Socin's supporting apparatus (Fig. 571). This apparatus has rubber rings attached, to produce flexion.

Fig. 571.



Socin's apparatus for flail-joint after resection of the elbow.

RESECTION OF THE SHOULDER.

With anterior longitudinal incision according to von Langenbeck (older method).

1. The patient lies on his back, the shoulder is pushed forwards by a cushion, the arm being held in such a position that the external condyle of the humerus is directed forwards.

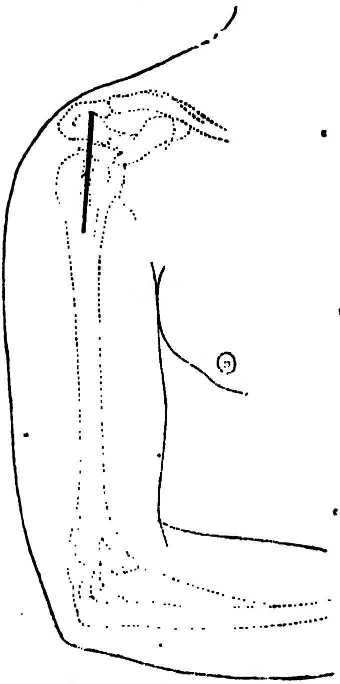
2. An incision is made, beginning at the anterior edge of the acromion, close to its articulation with the clavicle, running vertically downwards for 2 to 4 inches, and penetrating through the deltoid muscle to the fibrous capsule of the joint, and the periosteum (Fig. 572).

In order to spare the fibres of the deltoid and the circumflex nerve, the incision can (according to Ollier) be placed more to the inner side, and carried obliquely downwards and outwards from the outer edge of the coracoid process.

3. The margins of the incision through the muscle are drawn apart with blunt hooks; the tendon of the long head of the biceps is seen lying in its sheath (Fig. 573).

4. An incision on the outer side of the tendon opens its sheath; the knife, with its back turned towards the tendon, is made to run

Fig. 572.



Resection of the shoulder.
Anterior longitudinal incision according to von Langenbeck.

Fig. 573.

Tendon of the long head of the biceps.

up the groove between the tuberosities, and divides the entire sheath, together with the capsule of the joint, up to the acromion.

5. The tendon of the biceps is lifted from its groove, and held to the outer side with blunt hooks.

6. While an assistant slowly rotates the arm outwards, the knife, with its edge directed against the bone, makes a curved incision around the lesser tuberosity, beginning at the incision in the capsule, and divides the capsule and the insertion of the subscapularis muscle (Fig. 574).

Fig. 574.

Fig. 575.

7. The arm is again rotated inwards. The tendon of the biceps is drawn inwards, and there dropped.

8. The knife is once more carried from the incision in the capsule, around and above the greater tuberosity, in a larger circle, and divides the capsule, together with the insertions of the supraspinatus, infraspinatus, and teres minor (Figs, 575 and 576).

Fig. 576.

Muscles attached to the greater and lessor tuberosities.

9. The head of the humerus is thrust out of the wound by pressure from below, seized with a forceps (best with Farabœuf's forceps, Fig. 546 and 577), and, after the posterior attachment of the capsule has been divided, is sawed off with the keyhole saw (Fig. 578).

10. If the head of the humerus has been separated by the bullet, it must be seized and drawn out with a sharp bone hook (see Fig. 553), or with a bullet screw (see Fig. 307). If it has been broken into several fragments, they can be seized singly by the forceps, and detached with the blunt pointed (Fig. 579), or the probe pointed knife (Fig. 580).

11. In most cases operated upon according to this method, a flail-joint is formed, with dislocation of the upper end of the humerus, or

Fig. 577.

Fig. 578.

Sawing off the head of the humerus.

an awkward articulation with the coracoid process. Free active mobility is much more likely to result when the connection of all the muscles surrounding the joint with the capsule, and the periosteum of the shaft of the humerus, is carefully preserved at the time of operation. This is the advantage of the following operation.

Fig. 579.

Blunt-pointed knife.

Fig. 580.

Probe-pointed resection knife.

THE SUBPERIOSTEAL OR SUBCAPSULAR RESECTION OF THE SHOULDER.

According to von Langenbeck.

1 to 4 as in the preceding operation.

5. The periosteum is divided with the resection knife along the inner edge of the groove between the tuberosities, and carefully raised

with the narrow elevator, from the lesser tuberosity to the greater (Fig. 581).

6. The tendon of the subscapularis (Fig. 576) is separated from the bone with knife and mousetooth forceps, without destroying its connection with the detached periosteum. During this part of the operation, the arm must be slowly rotated outwards, and as the separation proceeds, the knife must be frequently alternated with the elevator.

7. The arm is again rotated inwards, the tendon of the biceps raised from its groove, and dropped on the inner side.

8. The periosteum of the outer surface of the neck of the humerus is detached from the great tuberosity, in connection with the insertions of the supraspinatus, infraspinatus, and teres minor, in the same way as in No. 6. This separation is somewhat difficult in primary resections, because the periosteum is usually very thin.

Fig. 581.

Ligaments of the shoulder-joint.

9. The head of the humerus is thrust out of the wound, and sawed off as in the operation previously described. If it is desired only to resect the head at the level of the upper border of the tuberosities (and this always gives the best results), there is then, properly speaking, no separation of the periosteum. The attachments of the muscles are merely dissected from the bone as far as is necessary, beginning in the cavity of the joint, and the only precaution required is not to cut them transversely, but to maintain their connection below with the bone. But as the head of the humerus can not then be made to protrude from the wound, it must be sawed off with the small keyhole saw, or with a chain saw.

10. After the hemorrhage has been arrested, an incision is made in the skin at the back of the wound cavity, at the posterior margin of the deltoid, through which a drainage tube is introduced into the cavity. The anterior wound can then be completely united with deep and superficial sutures.

An antiseptic cushion dressing, the bandages securing the arm, flexed at the elbow, against the thorax like a sling, fully provides for the fixation of the extremity.

RESECTION OF THE ARTICULAR SURFACES OF THE SCAPULA.

1. In resection of the shoulder joint, nothing is removed from the scapula unless this bone has also been injured by the bullet. But if the **articular surfaces of the scapula alone** are comminuted, and the head of the humerus uninjured, it is only necessary to remove the former.

Fig. 582.

Resection of the glenoid process of the scapula.

2. When the gunshot wound does not (as usual) indicate the site of the incision, the best method of opening the joint is the following: —

3. A curved incision, which surrounds the posterior edge of the acromion, and separates the fibres of the deltoid from it, exposes the posterior surface of the capsule of the joint (Fig. 582).

4. From the middle of this incision, the knife is directed upon the posterior superior border of the glenoid process of the scapula, and cutting vertically downwards between the tendons of the supraspinatus and infraspinatus to the middle of the great tuberosity, divides the capsule of the joint, and at the same time the skin and the deltoid muscle — the latter in the direction of its fibres.

5. While the soft parts are strongly retracted, the tendon of the long head of the biceps and the capsule are separated from the margin of the glenoid process, in connection with the periosteum of the neck of the scapula, on every side, far enough to allow the removal of the articular surface with the keyhole saw, or the extraction of the fragments of the shattered bone with the knife.

6. The after-treatment is the same as in resection of the shoulder joint.

RESECTION OF THE ANKLE-JOINT.

Subperiosteal, according to von Langenbeck.

1. The foot rests upon its inner side, and a vertical incision $2^1/_2$ inches in length, is made along the posterior margin of the lower end of the fibula; then, bending like a hook around the external malle-

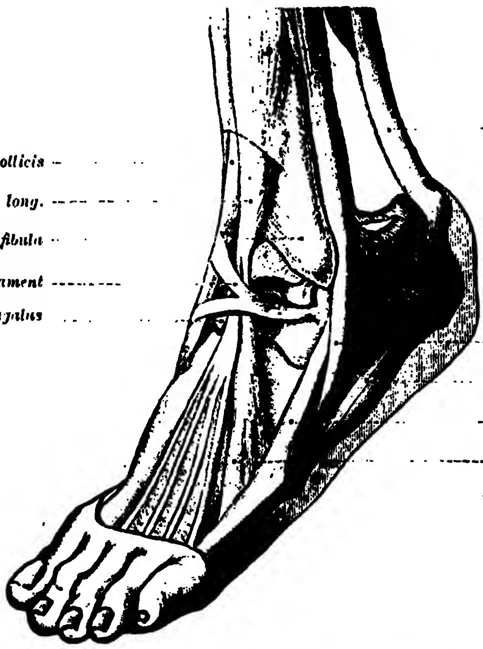
olus, it extends up the anterior margin for $^1/_2$ inch. This incision penetrates to the bone throughout its entire extent (Fig. 583).

Fig. 583.

2. The periosteum, together with the skin, the muscles, and the sheaths of the tendons, is raised with the raspatory and elevator from the anterior and posterior surfaces of the bone, until a keyhole or chain saw can be introduced behind the fibula, at the upper end of the incision (Fig. 584).

NB. The sheath of the tendon of peroneus longus muscle must be spared if possible.

Fig. 584.

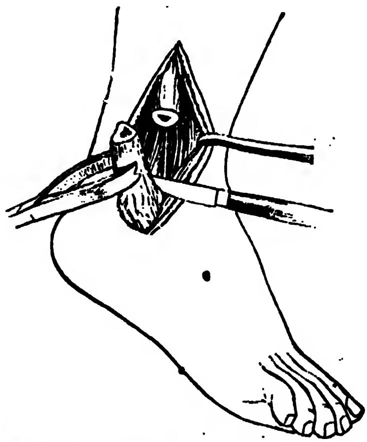


External aspect of the left ankle (according to Henke).

3. The fibula is sawed through, the piece sawed off is seized with the bone forceps, drawn forwards with gradually increasing force (Fig. 585), and separated from the interosseous ligament. Finally,

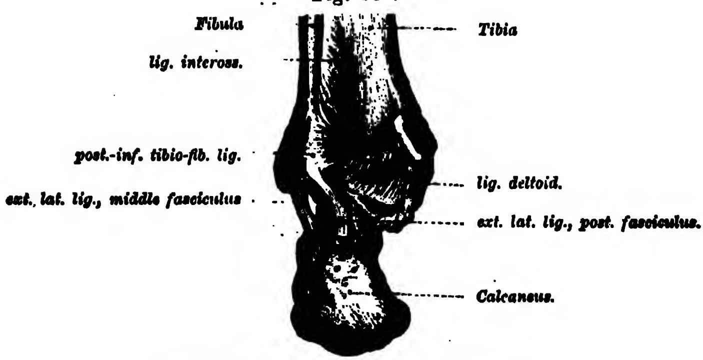
cutting from above and on the inner side, the posterior inferior tibio-fibular ligament (the lower, very firm part of the interosseous ligament) (Fig. 586), and the three strong fasciculi of the external lateral ligament (Fig. 587), are divided close to the bone.

Fig. 585.



Dissecting out the lower end of the fibula.

Fig. 586.

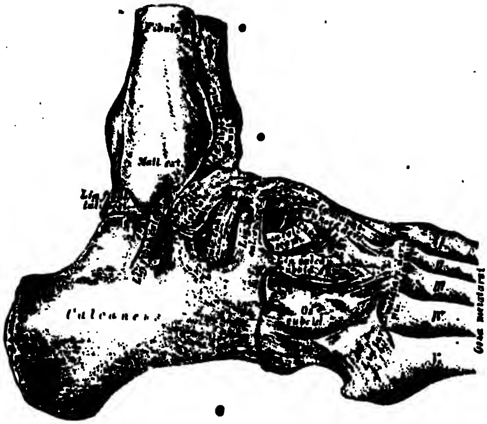


Ligaments of the ankle-joint (posteriorly).

4. The foot is turned so as to rest upon its outer side, and a semicircular incision, $1^{1}/_{4}$ to $1^{3}/_{4}$ inch long, is carried around the lower border of the internal malleolus (Fig. 588), and from the middle of this incision, a second vertical cut, 2 inches long, is made upwards, on the inner surface of the tibia (anchor-shaped incision).

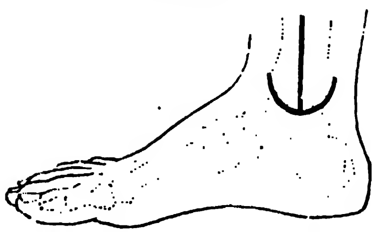
5. The incision penetrates through the periosteum to the bone. The periosteum is detached in two triangular flaps, together with the

Fig. 587.



Ligaments of the ankle-joint (externally).

Fig. 588.



Incision over the internal malleolus.

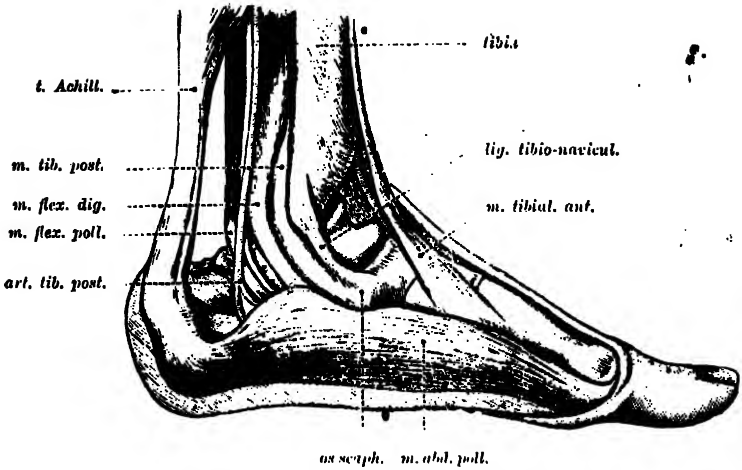
skin on the inner side (Fig. 589), with the sheaths of the tendons of the extensors on the anterior surface, and with the sheaths of the flexors on the posterior surface of the tibia. Finally, the deltoid ligament is cut away from the edge of the malleolus (Fig. 590).

6. At the upper end of the longitudinal incision, the tibia is sawed across with the keyhole or chain saw — in an oblique direction, on account of the limited space. The piece which is sawed off is seized with the bone forceps, and while the elevator presses down the periosteal surface of the interosseous ligament from above, the fragment is gradually turned out of the wound.

NB. The preservation of the interosseous membrane is especially important for the regeneration of the bone (von Langenbeck).

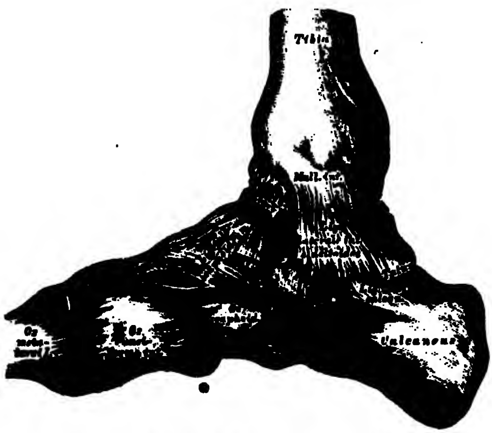
7. The bone is now held only by the anterior and posterior attachment of the capsule of the joint. This is divided with the knife, and in so doing the tendon of the tibialis posticus must not be injured.

Fig. 589.



Internal aspect of the ankle (according to Henke).

Fig. 590.



Ligaments of the ankle-joint (internally).

8. If it is desired to remove the upper articular surface of the astragalus, it should be done with the keyhole saw, sawing off the articular surface from before backwards, in the line of the semicircular incision in the skin, while the sole of the foot is held firmly against the top of the table by two hands (von Langenbeck advises to saw off the superior articular surface of the astragalus directly after division of the fibula, through the first incision, but not to extract it with the elevator until the tibia has been removed).

9. If the entire astragalus is comminuted, or its upper articular surface has been splintered, the whole bone must be removed.

10. To accomplish this removal, the vertical incision on the inner side which passes over the point of the malleolus, is prolonged downwards in a curve convex below, parallel to the tendon of the tibialis posticus, as far as the tuberosity of the scaphoid. The tendon of the tibialis anticus, and the anterior tibial artery are drawn outwards; and the fibres of the internal lateral ligament which are attached to the scaphoid (Fig. 589), and the astragalo-scaphoid ligament (Fig. 590), are cut through. The joint between the astragalus and scaphoid is then opened from above and from the inner side.

11. Then the incision on the external side is also carried from the external malleolus horizontally across the depression below it, the strong ligaments of that region (external lateral ligament, anterior calcaneo-astragaloid ligament, and the interosseous calcaneo-astragaloid) (Fig. 587) are divided. Finally, while the bone is twisted out with bone forceps and elevator, the remains of the capsule of the joint are severed.

12. A short drainage tube is inserted on both sides into the cavity between the bones, after careful ligature of all the wounded vessels, and the wound is then sutured.

13. If it has been necessary to remove the whole of the astragalus, it is well to drive a long nail from the sole through the os calcis into the tibia, in order to secure the bones at right angles to each other.

14. The limb is secured by one of the dressings shown in figures 144, 150, 188 to 190, 200 to 203, 284, so that the foot is at right angles to the leg.

OSTEO-PLASTIC RESECTION OF THE TARSUS.

According to Mikulicz-Wladimiroff.

In extensive injuries of the posterior part of the tarsus, as far back as the ankle, the anterior part of the foot can be preserved by this operation, and made to unite with the bones of the leg, after their articular surfaces have been sawed off, in a position like that of talipes equinus, so that when recovery has taken place the individual walks on the heads of the metacarpal bones. The operation is performed as follows: —

1. A transverse incision, which begins on the inner border of the foot in front of the tuberosity of the scaphoid, and ends on the outer border behind the tuberosity at the base of the fifth metatarsal, divides the soft parts of the foot down to the bone.

2. A second transverse incision, which passes above the heel, from the posterior edge of the internal malleolus to the posterior edge

of the external malleolus, divides the tendo Achillis, together with the other soft parts, on a level with the tibio-tarsal joint.

Fig. 591.

3. The ends of the two transverse incisions are joined by two cuts which run obliquely, from behind forwards, and from above downwards, and penetrate to the bone at one stroke.

4. The foot is strongly flexed, and the posterior part of the capsule, and the lateral ligaments of the tarso-tibial articulation, are divided by bold cuts.

5. The astragalus and os calcis are carefully dissected from the soft parts of the dorsum of the foot, and disarticulated at Chopart's joint.

6. The malleoli are sawed off, together with the articular surface of the tibia; and then the articular surfaces of the scaphoid and cuboid are also removed (Fig. 592).

Fig. 592.

7. All the injured vessels, especially the posterior tibial artery, and the peripheral stumps of the external and internal plantar arteries, are carefully ligated.

8. The foot is placed in the position of an extreme talipes equinus, bringing the sawed surfaces of the cuboid and scaphoid bones in contact with the bones of the leg. They are at once secured by strong catgut sutures, or are nailed together with a long steel nail, inserted obliquely, after the wound has been closed (Fig. 593).

Fig. 593.

Fig. 594.

9. The tendons of the plantar flexors are cut subcutaneously, so that the toes can be over-extended at right angles to the sole.

10. The superabundant soft parts of the dorsum are drawn together by deep sutures of catgut, and then the edges of the wound are united by superficial sutures, leaving openings for drainage (Fig. 594).

RESECTION OF THE KNEE-JOINT.

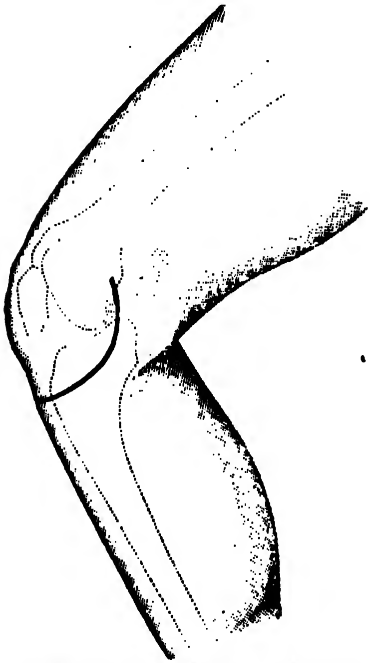
With anterior curved incision.

1. The knee being flexed to a right angle, an incision (Fig. 595) is carried in a curve from the posterior edge of one epicondyle to that of the other, just above the tuberosity of the tibia, dividing the

ligamentum patellae and the anterior part of the capsule of the joint at the same time.

2. The leg being more strongly flexed, both lateral ligaments are separated from the femur, and then the crucial ligaments (Fig. 596). The joint gapes widely.

Fig. 595.



Resection of the knee with anterior curved incision.

Fig. 596.

Crucial ligaments.

3. The posterior part of the capsule is detached from the femur with cautious strokes of the knife, always directed against the bone. The great vessels of the popliteal space may be injured by cuts directed carelessly backwards (Fig. 597).

4. The end of the femur is made to project, and is sawed off, so far as it is covered with cartilage, parallel with its articular surface.

5. The articular surface of the tibia is sawed off in the same way, without injury to the fibular articulation, which does not generally communicate with the knee-joint.

6. The patella is dissected out, and separated from the tendon of the extensors. The superior pocket of the capsule must also be extirpated, if it is diseased.

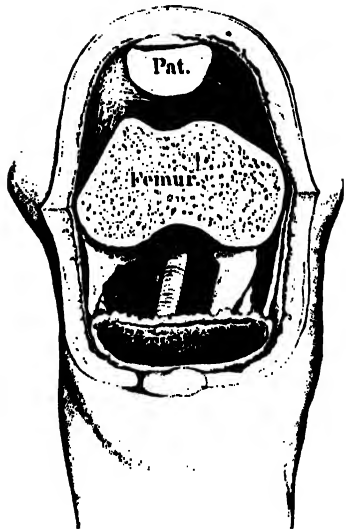
7. The knee-joint can also be very quickly opened and inspected in its whole extent, by a curved incision, convex above, which

divides the tendon of the quadriceps from the patella (E. Hahn). This method is especially suited to those cases in which the condyles of the femur have been broken into several large fragments by the bullet, while the tibia has escaped injury. If it is desired in such cases to attempt to save the condyles, they must be fastened together with silver wire or nails.

If the patella is sound, it can also be nailed to the condyles after its articular surface has been sawed off.

8. As the chief object in the treatment of the severer injuries of the knee-joint is to secure ankylosis in extension, and not a movable joint. the sawed surfaces of the bones must be exactly fitted to eachother and securely retained in contact.

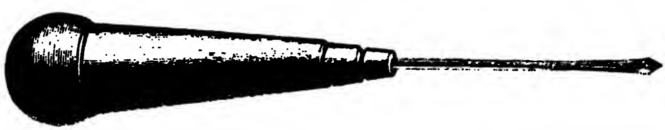
Fig. 597.



Position of the popliteal vessels in resection of the knee.

9. For this purpose, holes can be bored obliquely in corresponding places in both bones, with a fine **bone awl** (Fig. 598), having a small eye near its point, and strong catgut strands or silv drawn gh the holes, with which to fasten the sawn surfaces together.

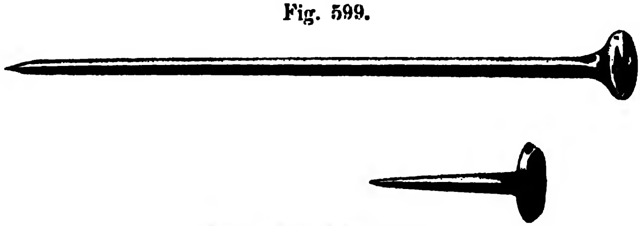
Fig. 598.



Bone-awl.

10. It is still better (according to E. Hahn) to secure the bones with nails. After the wound has been closed, and before the dressing has been applied, long **steel nails** (Fig. 599) (of which an assortment

Fig. 599.



Steel nails (Nos. 1 and 5).

of sizes must be at hand) are made to penetrate the skin on each side of the femur, and driven obliquely through both bones with a hammer (see also Fig. 50).

11. The bones will generally be found firmly united when the dressing is removed, during the fifth or fourth week. The nails have become loose in the meantime, and can be easily extracted by a slight twisting movement, and the small canals left by them heal in a few days.

12. The resected knee-joint is **drained** by two tubes which are inserted in the two angles of the curved incision, and a third which is introduced in front, in the pocket of the capsule lying under the extensors.

An attempt is made to diminish the cavities of the wound as much as possible, by deep sutures placed in different parts before the wound is closed.

The drainage tubes may be dispensed with, if all the injured vessels, which are easily recognized, when the operation is carefully performed with the bloodless method, are at the same time properly ligated, for simply leaving the angles of the wound open will suffice for drainage.

13. It is very important that the **dressing** should secure the bones in their position, exercise equable compression on every side of the cavity of the wound, and entirely prevent the entrance of the agents of decomposition.

If the dressing accomplishes these ends, it may be allowed to remain until the wound has completely healed — five to six weeks.

14. A **cushion-dressing** is excellent (see page 27), and this is best applied in the position shown in Fig. 50, and in the following manner: —

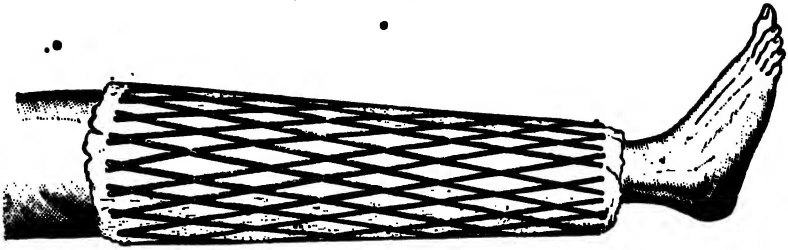
15. Small cushions, or bunches of crumpled gauze, are placed upon every spot where the soft parts yield easily to the pressure of the finger, and over them a moderately large cushion, which surrounds the entire region of the knee on every side.

The limb is to be surrounded with aseptic cotton batting, from the lower edge of the cushion to the ankle, and from its upper edge to the constricting band, which has been applied just below the fold of the groin, and then cushion and cotton are firmly bandaged with a gauze bandage wet with bichloride solution.

16. A well disinfected flower-pot trellis (Fig. 600) is placed over this inner dressing, and also firmly secured with a gauze bandage. This gives the dressing such rigidity, that the limb can be lifted by the heel, without disturbing the relative positions of the resected bones.

17. The large outer cushion is applied outside of this, enclosing the entire inner dressing, and is secured with wet starched gauze bandages.

Fig. 600.



Flower-pot trellis, applied.

18. The limb is then very carefully placed upon a flat leg-splint (see Figs. 144, 146, 150, 188, and 284), upon which the padding must be so arranged that the parts which are not enclosed in the dressing are well supported, and especially that the heel shall not suffer from pressure. The limb is secured in position on the splint with wet gauze bandages, after the constricting band has been quickly removed.

19. Then the limb is raised to the perpendicular, in order to diminish the blood-supply. The patient is carried to his bed in this position, and the elevation is maintained for several hours afterwards. The patient can generally be spared all loss of blood by this method of treatment (compare pages 184 and 228).

But if the injured vessels have not been ligated with sufficient care, it may happen that the oozing blood will penetrate the dressing, and appear on its lower surface, a few hours after the extremity has been released from its elevated position.

NB. Naturally the blood will first be seen in the interrupted wire splints (Figs. 284 and 146), for in the solid splints (Figs. 144, 150, and 188) it will not become visible until it reaches the upper posterior edge of the splint.

In such cases there must be no delay in immediately renewing the outer dressing, as has been described on page 40.

After cutting the outermost bandage, the limb is lifted from the splint, the outer larger cushion is removed, the inner cushion and the flower-pot trellis are abundantly irrigated with carbolic or bichloride solution wherever they are stained with blood, a fresh large cushion is applied, and the limb again placed on a freshly padded splint.

In these cases the advantage of the inner flower-pot trellis splint is particularly evident, for it renders it possible to renew the dressing without causing pain to the patient, and without disturbing the relative position of the bones.

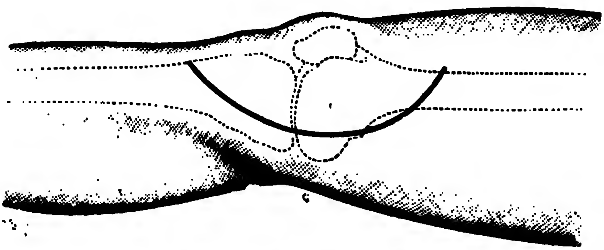
In cases where there are hopes of preserving a movable joint for the patient, subperiosteal resection of the knee may be attempted.

SUBPERIOSTEAL OR INTRACAPSULAR RESECTION OF THE KNEE-JOINT.

With lateral curved incision according to von Langenbeck.

1. A curved incision, 6 to 8 inches long, is made on the inner side of the joint (held in a position of extension), beginning 2 to $2^1/_2$ inches above the patella, on the inner margin of the rectus muscle, passing over the posterior edge of the internal epicondyle with its convexity backwards, and ending 2 to $2^1/_2$ inches below the patella at the inner side of the crest of the tibia (Fig. 601).

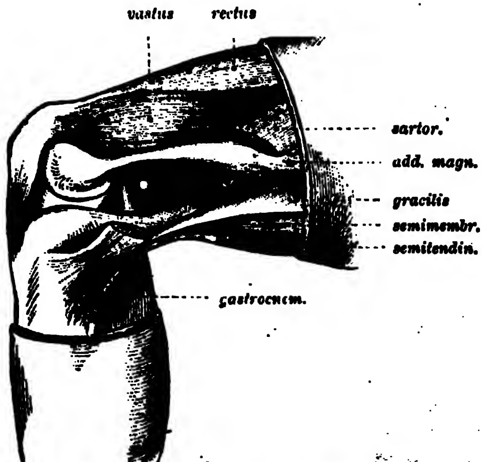
Fig. 601.



Resection of the knee joint with lateral incision according to von Langenbeck.

2. In the upper part of the wound lies the vastus internus, and below it appears the tendon of the adductor magnus; in the lower part is seen the tendon of the sartorius; neither of these tendons should be injured (Fig. 602).

Fig. 602.



Tendons at the inner side of the knee-joint.

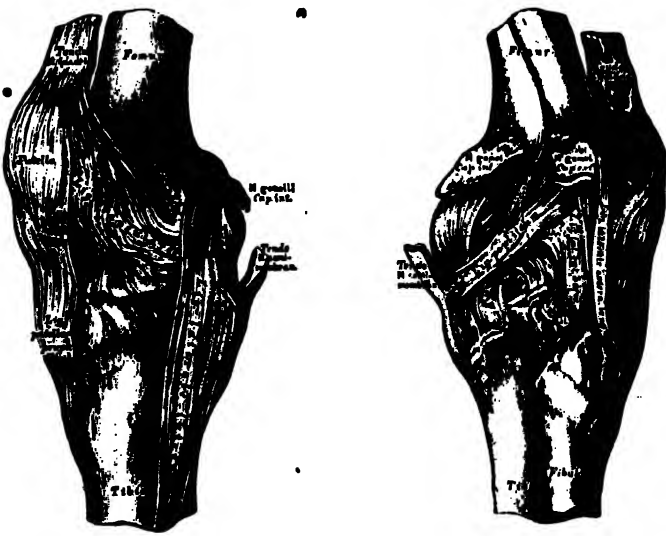
3. The internal lateral ligament is cut across at the level of the joint, the attachment of the capsule on the inner side is separated from the anterior margin of the internal condyle, up under the vastus internus, and the ligamentum alarium internum is also detached from the anterior edge of the tibia as far as the middle line (Fig. 603).

4. The knee is flexed, and, while it is slowly extended again, the patella is forcibly dislocated outwards.

5. The crucial ligaments are cut through; in order to divide the posterior crucial ligament from the intercondyloid spine of the tibia, the internal condyle of the tibia must be rotated forwards.

6. The external lateral ligament, with the neighboring part of the capsule, is cut through by a deep semi-circular incision, which is made a few lines below the point of the internal condyle (Fig. 604).

Fig. 603. Fig. 604.



Internal. External.

Ligaments of the right knee-joint.

7. The joint gapes widely. The posterior part of the capsule is cut through, the articular ends of the femur and the tibia are in turn made to protrude, and as much sawed away as seems necessary.

8. If it is desired to remove the patella, the margin of its cartilaginous surface must be cut around with the knife, and the bone then extracted with raspatory and elevator from its periosteum, so that the latter remains in connection with the ligamentum patellae, and the tendon of the extensors.

Before the wound is closed, a large drainage tube is placed in the most dependent part. It is advisable also to make a small counter-opening on the outer side, from which the other end of the tube is made to project, and also to pass a drainage tube through the upper pocket of the capsule.

If **inflammation and suppuration of the synovial membrane** develop after injury to the capsule of the knee-joint, without important injury of the bones, recovery with a movable joint can be obtained by drainage.

DRAINAGE OF THE KNEE-JOINT.

(Compare page 156).

1. In order to thoroughly irrigate the joint with antiseptic solutions, and to supply free outlet to the effused pus, it is enough in less severe cases to make incisions 1 to $1^{1}/_{2}$ inch long on each side of the patella, and to insert short drainage tubes into them which are cut off at the level of the skin, and held in position by a suture or a safety-pin.

2. After the joint has been thoroughly irrigated through these drainage tubes, first with a solution of salt, and then with 1 to 1000 bichloride, a firmly compressing antiseptic dressing is applied which squeezes all fluid from the joint, and the entire limb is then well immobilized, as after a resection.

3. If the temperature then becomes normal again, and the pain disappears, the dressing may remain untouched for several days, even for weeks. Otherwise, the dressing must be renewed every day, and the antiseptic irrigation repeated.

4. In severer cases the upper pocket of the capsule, the bursa of the extensors, is drained by incisions on each side, above the patella; and if the capsule has already burst, and the pus has made its way under the quadriceps femoris, this pus cavity must also be drained by sufficiently large incisions at its upper end.

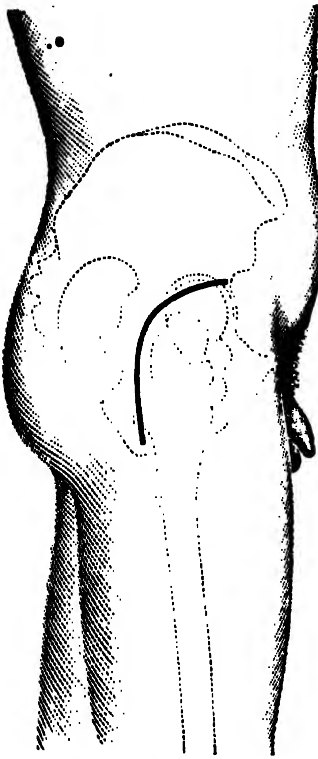
RESECTION OF THE HIP-JOINT.

With posterior curved incision according to Anthony White.

1. The patient lies upon the sound side. The incision begins half-way between the anterior superior spine of the ilium, and the great trochanter, is carried in a curve over the apex of the latter, and passes downwards along its posterior margin for about 2 inches (Fig. 605).

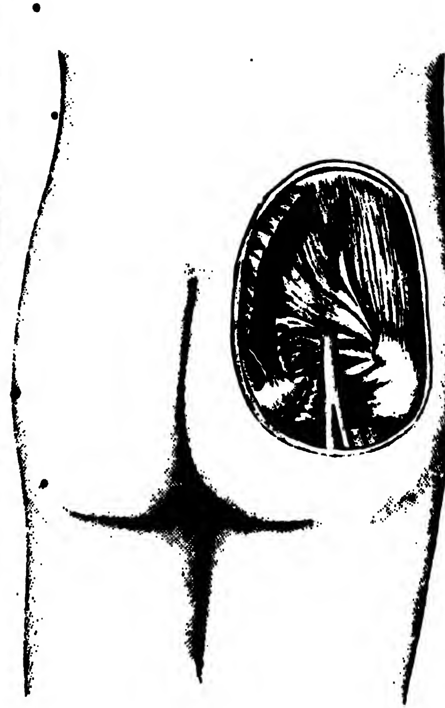
2. The tendinous attachments of the glutei medius and minimus, the obturators, the pyriformis, and the quadratus (Fig. 606) are de-

Fig. 605.



Resection of the hip-joint.
Posterior curved incision according to A. White.

Fig. 606.



Muscles behind the hip-joint, and the sciatic nerve.

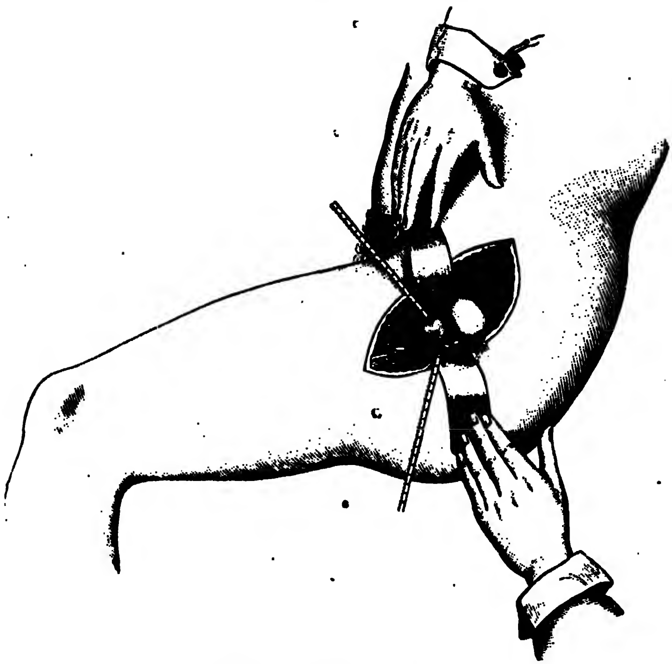
tached from the trochanter with a short strong knife, and the muscular masses drawn apart with retractors, so that the posterior superior surface of the neck of the femur and the acetabulum are visible.

3. A bold cut along the edge of the cartilaginous rim opens the joint, and as the thigh is flexed and abducted, the head of the femur comes half-way out of the acetabulum with a sucking sound.

4. With a narrow knife, which enters the acetabulum from behind and externally, the ligamentum teres is divided against the head of the femur, and the latter escapes entirely from the acetabulum.

5. The soft parts are held back with a strip of brass which is passed behind the neck of the femur, and the latter is divided by the keyhole saw or the chain saw, while the head is held by the bone forceps (Fig. 607). [For the conclusion of this operation, see the following].

Fig. 607.



Resection of the hip-joint.

Sawing off the head of the femur with the chain saw, while the soft parts are retracted with a strip of brass.

SUBPERIOSTEAL RESECTION OF THE HIP-JOINT.

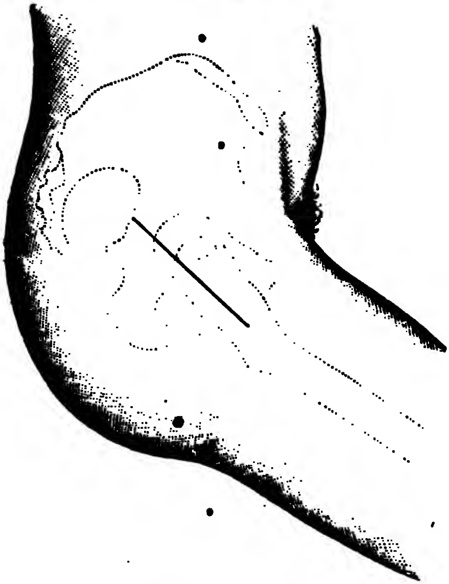
With longitudinal incision according to von Langenbeck.

1. The thigh being flexed to 45°, a **straight incision**, about 5 inches long, is made from the middle of the trochanter, upwards and backwards towards the posterior superior spine of the ilium, in the direction of the long axis of the femur (Fig. 608).

2. The incision penetrates between the bundles of fibres of the gluteus maximus, and divides the fascia of the thigh, and the periosteum of the trochanter.

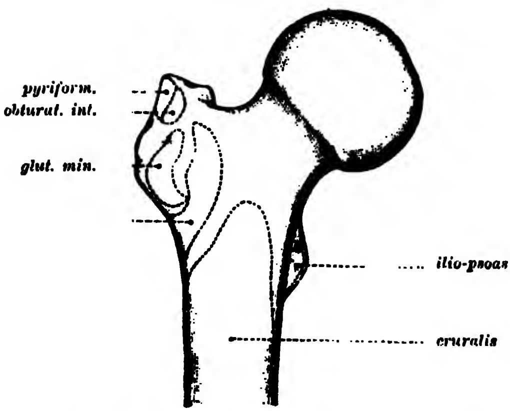
3. While the edges of the wound are strongly drawn apart with retractors, all the muscles which are attached to the trochanter (on the anterior surface, the gluteus minimus, pyriformis, obturator internus, and gemelli (Fig. 609); on the posterior surface, the gluteus medius and quadratus femoris (Fig. 610)) are separated with the knife through this incision, but the surgeon should endeavor to preserve their connection with the fascia of the thigh and the periosteum of the femur.

Fig. 608.



Resection of the hip.
Longitudinal incision according to von Langenbeck.

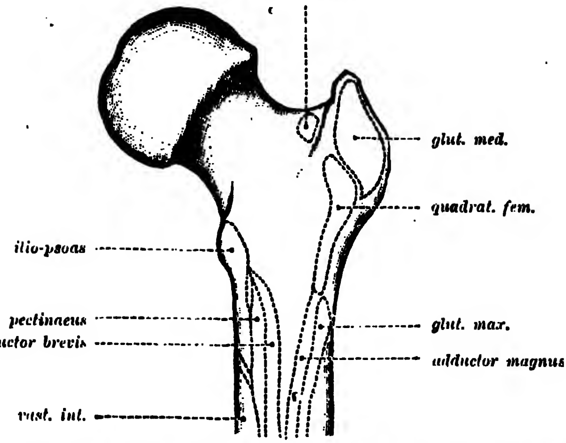
Fig. 609.



Upper extremity of the right femur with its muscular attachments (anteriorly).

This fatiguing task can be considerably facilitated (according to König) by cutting off the superficial layers of the anterior and posterior surfaces of the great trochanter with two strokes of a chisel, and,

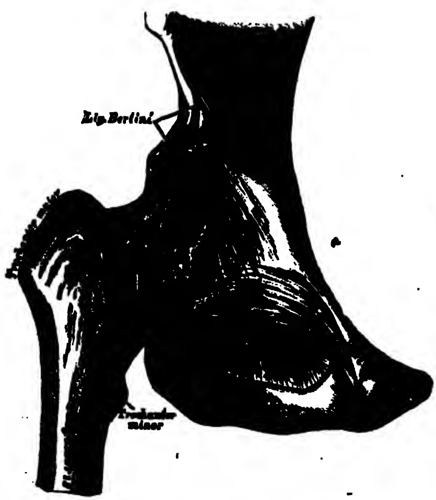
Fig. 610.



Upper extremity of the right femur with its muscular attachments (posteriorly).

without dividing the periosteum at the lower edge of the cuts, breaking off both layers of bone by bending the chisel sideways like a lever. Then the three-cornered piece at the apex of the trochanter between the two is cut off transversely, and the neck of the femur is exposed.

Fig. 611.



Ligaments of the hip, anteriorly.

4. A bold longitudinal incision is made upon the neck of the femur with a strong knife, and is repeated until the tough fibres of the capsule and the periosteum are completely divided.

5. Beginning from this incision, the periosteum, together with the capsule and the attachment of the obturator externus, is detached on all sides from the neck of the femur, with alternate use of the elevator and knife (Fig. 611).

6. The cotyloid ligament is then incised, and a piece removed from it on both sides, with the knife.

7. The thigh is next adducted and rotated inwards,

and, with a sucking sound, the head of the femur comes half-way out of the acetabulum.

8. A long narrow knife is made to enter the acetabulum from behind and externally, and divides the tense ligamentum teres by a cut directed against the head of the femur, in a direction inwards and forwards. The entire head then appears through the wound in the capsule and can be sawed off as described above.

9. If the neck of the femur has been shot away, the head must be fixed and its movements directed with the resection forceps, a sharp resection hook, or a bullet screw (see Fig. 508).

10. If the great trochanter is also injured, a piece of it is removed at the same time as the neck of the femur, by giving an oblique direction to the saw.

11. A large drainage tube is inserted as far as the acetabulum, after arrest of the hemorrhage, being brought out through the middle of the wound. The remainder of the wound is closed with sutures.

RESECTION OF THE HEAD OF THE FEMUR.

With anterior longitudinal incision according to Lücke and Schede.

This method is suitable for those cases in which the bullet has entered from the front, and shattered the head or neck of the femur, or in which an abscess has formed in front of the joint after suppuration of the latter.

1. The incision begins directly below the anterior superior spine of the ilium, and one finger's breadth internal to it, and is carried straight downwards for 4 or 5 inches.

2. The internal edges of the sartorius and rectus femoris are exposed and drawn outwards.

3. Tearing the loose cellular tissue of the interval between the muscles apart with the finger or with the dressing forceps, the outer edge of the ilio-psoas is found, and drawn inwards with a retractor.

4. The limb being somewhat flexed, abducted, and rotated outwards, the capsule of the joint appears.

5. The capsule is opened, and incised upwards and downwards as far as possible, with a probe-pointed knife.

6. The neck of the femur is stripped of periosteum with the elevator, and sawed transversely to its long axis with the keyhole saw introduced upon the finger — that is, the direction of the saw-cut should be from above outwards to below inwards.

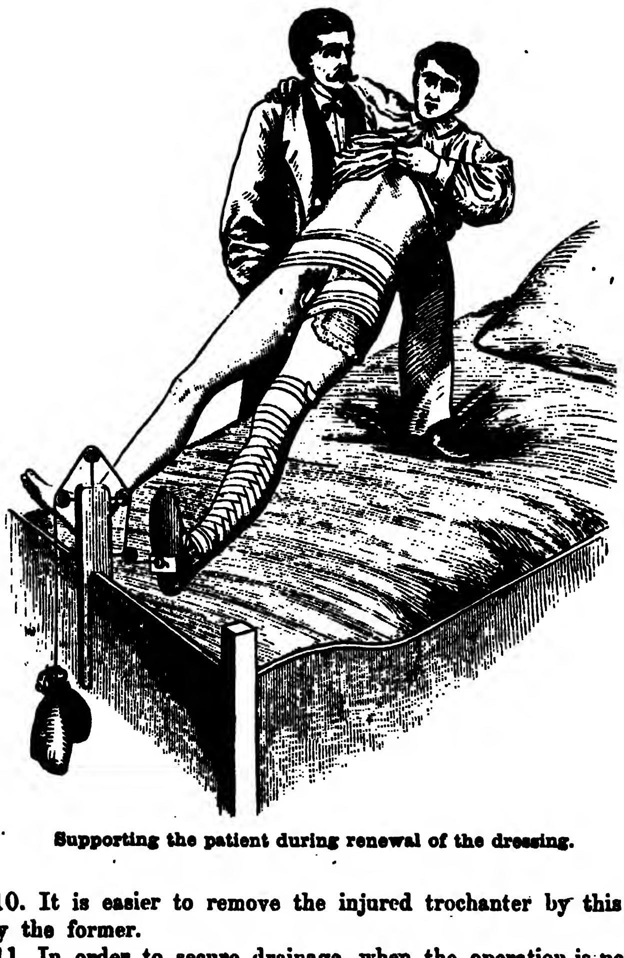
7. The cotyloid ligament is divided by short strong cuts upon the edge of the acetabulum, and the head of the femur extracted with a forceps or sharp spoon after the ligamentum teres has been divided.

8. Hüter has modified the method by making the incision from a point half-way between the anterior superior spine and the trochanter, obli-

quely downwards and inwards, along the external margin of the sartorius, for 4—6 inches.

9. Above, where the incision only divides the external fibres of the vastus internus, it penetrates to the bone at once, but in the lower angle of the wound it is shallower, in order not to injure the external circumflex artery of the femur, which runs transversely just below the trochanter.

Fig. 612.



Supporting the patient during renewal of the dressing.

10. It is easier to remove the injured trochanter by this method than by the former.

11. In order to secure drainage, when the operation is performed according to these methods, drainage tubes must be introduced into the cavity of the wound posteriorly, through the middle of the gluteus

maximus, and internally, behind the adductors, with the aid of dressing-forceps.

12. After the completion of the operation, an extension dressing is at once applied in the position shown in Fig. 47, page 31, and counter-extension secured by elevating the foot of the bed.

13. The most difficult task of the after-treatment is to renew the dressing without interfering with the action of the extension.

14. This may be accomplished by having a strong attendant place his foot on the bed, and letting the body of the patient rest upon his flexed thigh while the dressing is changed (Fig. 612). Or the apparatus shown in Fig. 234 on page 115, may be employed, as it leaves the region of the hip free, so that the dressing can be easily renewed.

15. The action of the extension continues while this apparatus is in use. (In order to avoid complication, it is not represented in the figure.)

16. As soon as the wound is healed, the patient may be allowed to get up, and to go about with the protection of a plaster or starch dressing („tutor").

TREPHINING.

1. Resection of portions of the bones of the skull may be necessary: —

a. To thoroughly clean fresh, compound fractures of the skull, and to **disinfect** the cavity of the wound;

b. To correct **depression** of the bone which endangers life;

c. To extract **splinters of bone,** or **foreign bodies** (projectiles, the tips of knives or daggers which have broken off, etc.) which have penetrated the dura mater and the brain;

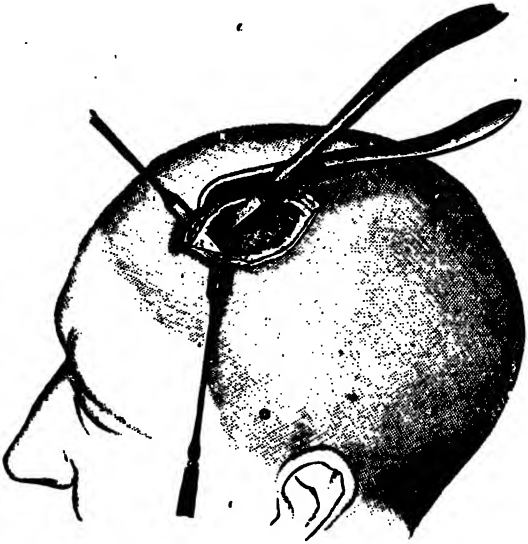
d. To secure drainage for fluids which have collected (blood, pus);

e. To arrest intracranial hemorrhage.

2. If there is an opening in the skull from fracture, but the piece of bone driven inwards is larger than the external opening, as is generally the case, the opening must be **enlarged,** in order to raise and extract the fragment.

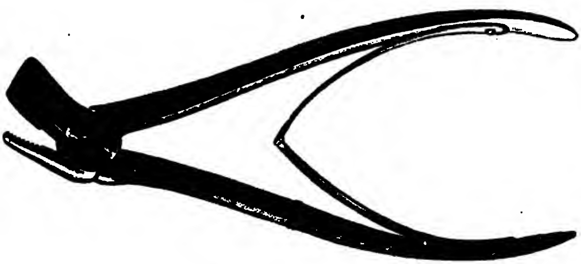
3. The best instrument for this purpose is Lüer's **rongeur** (Fig. 613), or Hoffmann's **gnawing forceps** (Fig. 614) if the outer opening is sufficiently large to permit the introduction of one arm of the forceps under the edge of the bone. Even if only a small portion can be gnawed from the edge at a time, the opening can be quickly enlarged in any direction.

Fig. 613.



Gnawing the edge of the bone with Lüer's rongeur.

Fig. 614.



Hoffmann's rongeur.

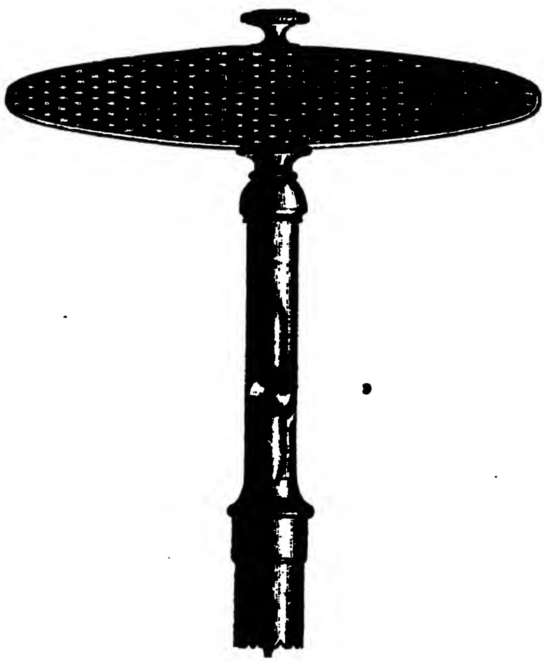
4. If the opening in the skull to be enlarged, is merely a narrow fissure, a gouge is used for the purpose (the common carpenter's gouge with a wooden handle is the best), and a wooden mallet, with which short quick strokes are given, the gouge being applied to the edge of the bone obliquely (Fig. 615). When the fissure has thus been carefully widened, so that the rongeur can be employed, the opening is enlarged with that instrument as before described.

5. As soon as the object pressing upon or penetrating the dura mater has been sufficiently exposed, it is raised with the elevator, seized with a forceps or dressing forceps, and carefully extracted. If

Fig. 615.

Gouging out the point of a dagger.

Fig. 616.



Trephine.

it is quite firmly wedged in the dura mater, it must not be forcibly removed, but should be released by incising the dura. If the base of the depressed bone is not completely broken across, it need not be taken away.

6. If a metal point which has been firmly wedged in the skull, and broken off close to the surface of the bone, is to be drawn out, it may be made accessible by cutting away the bone on opposite sides with the gouge (Fig. 615), so that it can be seized with a strong forceps, or still better with a small hand-vise such as watch-makers use.

Other foreign bodies also (hair, earth, pieces of cloth, etc.), which are caught in fissures in the bone, must be removed with the chisel in a similar way, so that no dirt shall be left in the wound.

Prolapsed portions of brain tissue, if indeed they have not been reduced to pulp, should not be cut away, for they may retract into the skull during the process of healing. But they must be carefully disinfected by irrigation with bichloride solution, etc.

7. **Resection of a circular piece of bone (trephining)** is only necessary in cases in which there is no opening in the skull. For this purpose the **trephine** is employed, and in almost all cases the smallest kind, to be operated by hand (Fig. 616), will answer. With this instrument a piece of bone as large as a five-cent piece can be removed.

8. If a wound in the scalp is already present where it is intended to trephine, it is enlarged by an incision penetrating to the bone. When there is no wound, it is best to make a semicircular incision down to the bone, and to detach the pericranium, together with the flap of the scalp, with the elevator, far enough to admit of applying the trephine (Fig. 617).

The neighborhood of the longitudinal and transverse sinuses, and of the middle meningeal artery, is to be avoided on account of the danger of hemorrhage (Fig. 618).

9. In order to begin the sawing action of the crown of the trephine, the central pin (the pyramid) is first made to enter the bone. This can be facilitated by previously making a small hole with a bone screw, or an ordinary awl.

As soon as the teeth of the crown have entered a little way into the bone, the pin of the trephine is drawn back into the crown.

10. The action of the trephine must be interrupted from time to time, partly to explore the depth of the cut in the bone with the flat end of a probe, or with a quill sharpened obliquely, partly to free the teeth of the crown from bone-dust, by brushing and washing it in carbolic solution.

11. If the bone has been entirely cut through at any point, the teeth must not be allowed to act upon that place, but only on those parts of the circle where the internal table has not yet been divided — by inclining the handle to one side. But before the bone is

Fig. 617.

Trephining.

Fig. 618.

Blood-vessels on the internal surface of the skull.

divided, a small bone screw (Heine's, Fig. 619) is screwed into the central hole made by the pin.

12. As soon as the button of bone is loose, it is carefully lifted out with a hook bent at a right angle, which is inserted into the hole in the head of the bone-screw. With the same hook it is ascertained if depressed fragments are movable (Roser), and an attempt to raise them or entirely remove them is made with it, or with a stronger elevator, or a forceps.

13. If serious **hemorrhage** from abnormally large veins of the diploe takes place in this operation, it can be arrested by plugging them with a ball of carbolized wax, softened in hot water, or a stout catgut thread. Hemorrhage from the branches of the middle meningeal artery can also be arrested by a ball of wax, if

Fig. 619.

Bone screw with Roser's hook.

it should be impossible to seize and ligate the wounded vessel. Hemorrhage from an injured sinus generally ceases after the application of a compressive dressing.

14. After completion of the operation, the entire wound, the injured dura, and even the exposed cerebral tissue must be irrigated with strong carbolic or bichloride solution, and a good antiseptic compressive cushion dressing applied, which is allowed to remain as long as possible.

15. If symptoms of increasing cerebral compression allow of the diagnosis of **intracranial hemorrhage** from the **middle meningeal artery**, the application of a **ligature** to its main trunk is indicated.

To expose the artery, the skull must be trephined in the middle of the flat temporal surface, at the intersection of a horizontal line drawn $1^1/_5$ inch above the zygomatic process with a vertical line drawn $^4/_5$ inch behind the ascending root of the zygoma. A flap is formed at this place with its base downwards, and its convexity directed towards the vertex, exposing the temporal muscle, which is divided in the direction of its fibres, and detached from the bone with the periosteal elevator on both sides of the incision. The pin of the trephine is then set upon the point of intersection of the lines described above, and a button carefully removed from the bone. The groove for the artery will be recognized on the internal surface of this button. The vessel is imbedded in the dura, and must therefore be surrounded by a catgut thread passed under it with a curved needle.

If the artery is not sufficiently exposed by this operation, the opening must be enlarged with the gnawing forceps, or with gouge and hammer.

TRACHEOTOMY.

1. It is necessary to **open the air-passages** whenever respiration is dangerously interfered with, in consequence of injury of the larynx, the trachea, or its neighborhood, or by oedema of the glottis, or the entrance of foreign bodies into the air-passages.

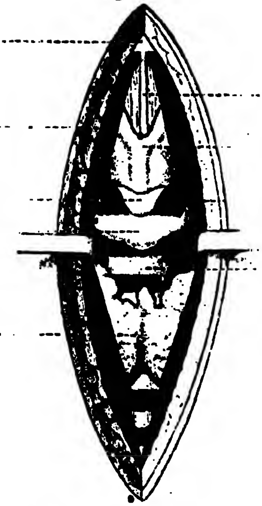
2. This is most easily and quickly done by division of the crico-thyroid ligament (**laryngotomy**), and this is satisfactory if it is only necessary to remove the immediate danger to life (Fig. 620).

3. If the opening is not sufficiently large, the cricoid cartilage may be divided at the same time (crico-tracheotomy).

4. The **trachea** is best opened above the thyroid gland (**tracheotomia superior**).

5. It is more difficult, and more dangerous, to open it below the thyroid gland (**tracheotomia inferior**) because in this situation the trachea lies much deeper, and not infrequently the large blood-

Fig. 620.



Larynx and trachea, anterior view.

vessels are found in front of it, when they take an abnormal course (innominate, carotid, and thyroid arteries; internal jugular and thyroid veins).

6. It is well to chloroform the patients for the performance of these operations, if they have not already become too far asphyxiated. The administration of chloroform considerably facilitates the performance of the operation, because the movements of the larynx are thus rendered quieter.

7. The head being bent far back, an incision about $1^1/_2$ inch long is made through the skin, exactly in the middle line, and it may be marked with a pencil beforehand.

8. The cellular tissue in the interval between the muscles is lifted up between two forceps, and divided as has been described in the account of the operation for the ligature of arteries (page 191). The sterno-hyoid muscles are retracted with blunt hooks (strabismus hooks, or eyelid retractors).

9. Every bleeding vessel is at once ligated, or, in case of need, secured with a suture. If haste is necessary, the bleeding vessels are seized with artery clamps, and the latter allowed to hang at the sides. The edges of the wound are thus held apart.

10. If the central portion (isthmus) of the thyroid gland extends to the upper rings of the trachea, or upon the thyroid cartilage, the posterior layer of the central fascia of the neck is incised with a small transverse cut in the middle of the cricoid cartilage, and separated from the trachea with a director, or with a strabismus hook (Fig.

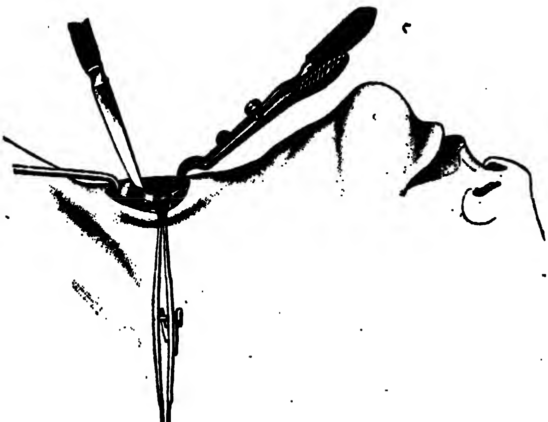
621). In this way access is gained to the parts behind the thyroid gland, and the venous plexus, without hemorrhage (Bose's retro-fascial dissection of the thyroid gland).

Fig. 621.

Strabismus hook.

11. As soon as the trachea is exposed, it must be held firmly, in order to open the anterior wall exactly in the middle line. It is best to steady it with a sharp hook (for instance, von Langenbeck's double hooks) (Figs. 622 and 623), the points of which are made

Fig. 622.



Tracheotomy.

Fig. 623.

von Langenbeck's double-hooks.

to seize the lower border of the uppermost cartilage. While the trachea is thus drawn upwards and steadied, the knife is inserted between the hooks, and made to penetrate about $^1/_2$ inch into the trachea, and then the anterior wall is divided as far as it has been exposed. Care must be taken not to cut the retracted cellular tissue, or the thyroid gland, for severe hemorrhage would follow, and the blood might enter the open tracheal wound. The thyroid gland should therefore be drawn downwards with a blunt hook.

12. The incision in the trachea is made to gape by separating the double hooks, and then the double tracheotomy tube of Lüer

Fig. 624.

Lüer's tracheotomy tube.

(Fig. 624) is immediately inserted. The tube is fastened around the neck with a rubber band.

13. Instead of the double hooks, two small hooks can be used to steady the trachea; or still better two **toothed clamp forceps** (Fig. 625), which are fastened in the wall of the trachea on each side of the middle line, and the sides of the incision at once separated when the knife enters.

Fig. 625.

Toothed clamp-forceps.

14. If no tracheotomy tube is at hand, a thick drainage tube is inserted, the lower end of which is cut obliquely; or two hooks are quickly made of silver wire (as is shown in Fig. 626) and these are hooked in the incision in the trachea, and held apart by a rubber band around the neck.

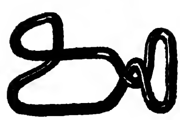
15. If nothing of the kind is to be had, a stout suture, or silver wire, is passed with a curved needle through each side of the incision, beneath one of the tracheal rings, and the threads are kept on the stretch by means of a rubber band around the neck.

16. But these expedients must give place to a tracheotomy tube as soon as possible, if the air-passages are to be kept open for a long time.

17. If blood enters the air-passages, it can be removed by suction through an elastic catheter.

18. Bullets and other foreign bodies which have entered the air-passages are to be sought for, and removed with forceps.

Fig. 626.



Retracting hook of wire.

19. After the operation has been completed, a piece of moist borated lint, or iodoform gauze, is laid upon the wound behind the tube, and the anterior surface of the neck is covered with a few layers of moist gauze. The inner tube must be removed from time to time and freed from mucus with a soft feather.

OPERATIONS UPON THE CHEST.

PARACENTESIS OF THE THORAX.

1. **Penetrating wounds of the chest** must be **immediately** closed with an antiseptic occlusive dressing.

Even gunshot wounds of the pleura and lung may then heal without sepsis and without suppuration.

The possession of an emergency dressing package (page 136) may be the means of saving life in such cases.

2. But if physical examination shows that air and fluid have entered the pleural cavity (**haemo- or pyo-pneumo-thorax**) and if the accompanying symptoms (high fever, fetid discharge) make it evident that **decomposition** has taken place, or if troublesome **symptoms of suffocation** are caused by the increased internal pressure in the thorax, there must be no delay in securing sufficient outlet for the collected fluid by making a free opening in the chest.

3. First, any existing wound is **enlarged** by incising the skin on each side of it in the direction of the intercostal space, far enough to permit the finger to penetrate into the chest. If this is difficult, the intercostal muscles are separated with the dilating forceps.

4. If it is found that a **rib** has been **shattered** by the bullet, the comminuted pieces must be **resected subperiosteally.** But even if the rib has not been injured, it is advisable to resect a piece of the nearest rib in all cases of empyema, because it is not possible to keep the opening in the intercostal space sufficiently large by the introduction of a drainage tube or canula, until the termination of the suppuration, as the ribs are drawn together by the cicatricial contraction of the wound.

5. When a free outlet is thus established, an attempt is first made to remove the secretion which has accumulated, and any chance foreign bodies (pieces of cloth, etc.) by abundant irrigation with warm salt solution.

6. **Inflation** with air by a syringe, and **proper position** of the body of the patient, so that the opening in the chest is at the most dependent point (both recommended by Roser) are efficient aids to the attainment of this object.

7. Then a large drainage tube, or several of them, are inserted into the chest, their ends are secured with silk thread or silver wire

to the surrounding skin, and finally the entire pleural cavity is again thoroughly washed out with an innocent disinfecting solution (aluminium acetate, chloride of zinc, thymol, borax).

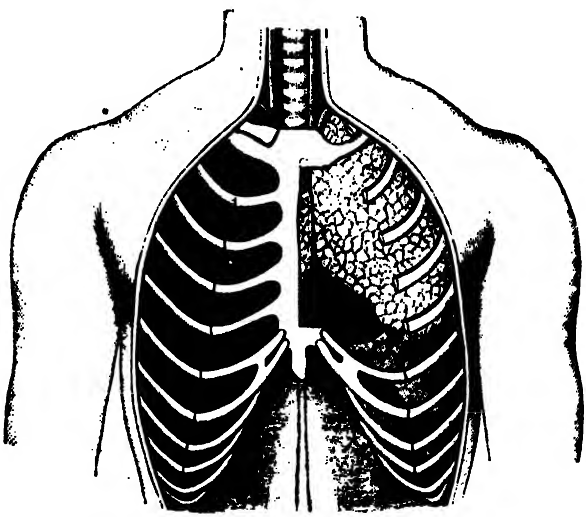
8. The drainage tubes must not be hermetically closed. They may be covered with a large cushion dressing of absorbent antiseptic material (crumpled gauze, peat, sawdust, moss, etc.), and the antiseptic irrigation repeated once or oftener every day. Or a smaller india rubber tube is inserted in the drainage tube, the lower end of which is suspended in a vessel partly filled with carbolic solution, into which the discharge can flow continuously.

If the wound is then surrounded with an antiseptic cushion dressing, it can sometimes be allowed to remain untouched for weeks.

9. If the external openings of the wounds have already cicatrized, or if they are in situations which do not permit free escape to the discharge (for instance, in the clavicular, or upper scapular regions) it is necessary to open the chest at some more suitable place (**paracentesis thoracis**).

10. The fifth or sixth intercostal space, half-way between the axillary and mammillary lines (Fig. 627) is preferred for this purpose;

Fig. 627.



Anterior view of the thorax.

or the neighborhood of the seventh rib, posteriorly, just below the lower angle of the scapula. It must be positively ascertained, by physical examination, that there is a collection of fluid, and not merely an adhesion between the lung and the costal pleura. In doubtful

cases this certainty can be obtained by aspiration with a hypodermatic syringe.

11. An incision $1^1/_2$ to 2 inches long is made at this place, close to the **upper margin of the lower rib** of the two between which it lies, because the artery and intercostal nerve run near the **lower edge of the upper rib.** A cautious dissection is made with the knife, until pus appears at some part of the wound, and then the opening is enlarged so as to secure free drainage.

12. But it is almost always necessary to resect greater or smaller portions of the neighboring ribs, in order to secure free drainage.

RESECTION OF THE RIBS.

Resection of the ribs is performed as follows: —

1. An incision, 2 to $2^1/_2$ inches long, made over the middle of the rib, parallel to its long axis, divides skin and muscles down to the periosteum.

2. The divided soft parts are retracted with sharp hooks. The periosteum is incised in the line of the wound, for a length of one inch or more. At each end of this incision, a transverse cut is made across the rib from one border to the other, and then the two periosteal flaps are detached upwards and downwards from the external surface of the bone, with the elevator.

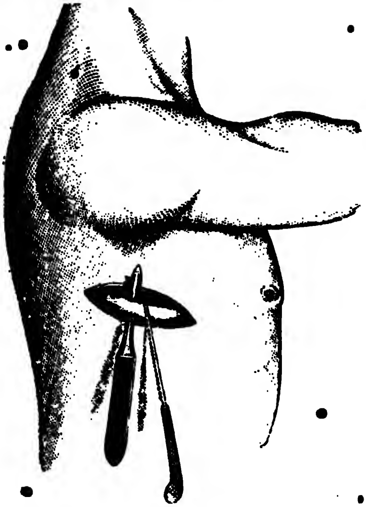
3. The periosteum is then carefully separated from the internal surface of the rib with a sharply bent elevator, beginning at the lower margin of the rib, and avoiding injury to the intercostal artery, which lies in the groove of the rib, until the point of the elevator can be passed out in the upper intercostal space between the periosteum and the bone.

4. Under the guidance of the elevator, a sufficiently large piece of the rib is then resected with the keyhole saw (Fig. 628), or with the American pruning-shears (Fig. 629).

5. Finally, the internal side of the periosteal cylinder, which now lies exposed in the bottom of the wound, together with the costal pleura which is adherent to it, is incised in the neighborhood of the upper margin of the rib, so as to allow a large drainage tube to be introduced into the chest-cavity.

6. Portions of the sternum can be resected in a similar manner with Lüer's rongeur (Fig. 613), if it appears necessary, in order to secure free escape to the contents of the pleural cavity, but it should be borne in mind that the **internal mammary artery** runs down behind the costal cartilages, along each side of the sternum, about $^1/_2$ inch from the edge of the latter (Fig. 620).

Fig. 628.



Resection of a rib with the keyhole saw.

Fig. 629.

American pruning-shears.

7. If it is desired to **ligate** this artery for hemorrhage, it must be exposed in this line by resection of the costal cartilages which lie in front of it.

INTESTINAL SUTURE.

1. If a loop of intestine protrudes through a wound of the abdomen, it must be returned as quickly as possible, with every antiseptic precaution, and the wound enlarged with the probe-pointed knife as far as may be necessary for this purpose. As soon as the intestine has been returned, the abdominal wound is carefully closed with deep and superficial sutures, and a good, antiseptic, compressive dressing applied. The position of the patient which is most convenient for the application of such a dressing is shown in Fig. 49.

2. If the **prolapsed loop of intestine** proves to have been wounded, the wound must be closed with sutures before the gut is returned.

3. Generally only the serous (peritoneal) surfaces of the intestinal wall unite, therefore the suture must bring these surfaces into contact, and for a considerable extent.

4. In **simple incised or punctured wounds**, the edges of the wound are turned in a little, and the folds sewed together with a fine

round sewing needle, and a fine antiseptic thread. The stitches are placed at intervals of about $^1/_8$ inch, and pass between the muscular layer and the mucous membrane (Lembert's intestinal suture) (Figs. 630 and 631).

Fig. 630.

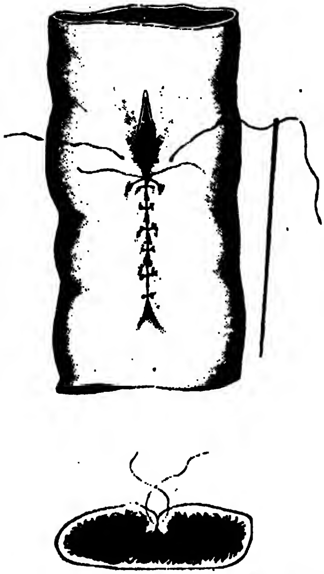
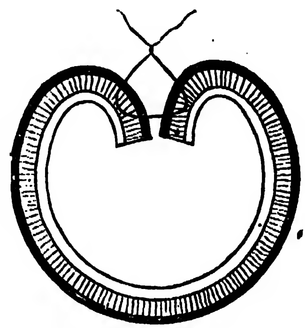


Fig. 631.



Lembert's intestinal suture.

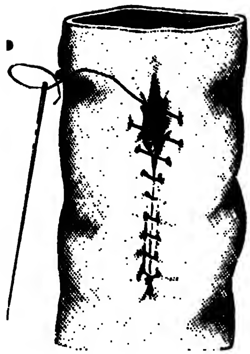
5. The **continuous** or **glover's suture** (Fig. 632), which can be more rapidly applied than the interrupted suture, may also be employed with good results.

6. An improvement of the Lembert suture is the **double intestinal suture** of Czerny (Fig. 633), which first brings the **raw edges** of the muscular and serous coats into contact, and, secondly, the serous surfaces.

7. If the **entire circumference of the intestine** has been involved in the wound, the edge of the lower end can be invaginated (according to Jobert), the upper end passed into it, and the two united with fine interrupted sutures, so that only the serous surfaces are in contact. As much of the mesenteric attachment of the two ends as interferes with the invagination, must be previously divided (Figs. 634 and 635).

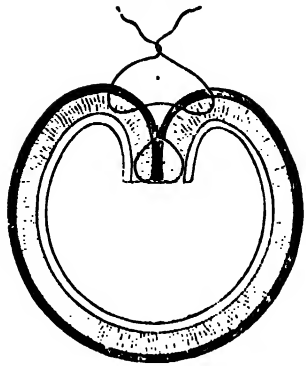
8. If an injury of the intestine is suspected in penetrating abdominal wounds, it is proper to open the abdomen in the middle line immediately (laparotomy), draw out the injured loop, and make an

Fig. 632.



Continuous suture.

Fig. 633.



Czerny's suture.

attempt to prevent the threatening septic peritonitis by closing the wound in the gut, and by antiseptic irrigation of the abdominal cavity.

Fig. 634.

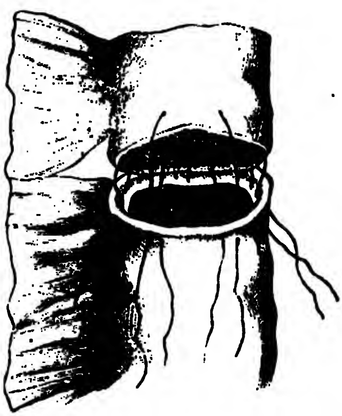


Fig. 635.

Jobert's intestinal suture.

9. If, in recent cases, a portion of the intestine is discovered to have been so lacerated and contused by the bullet that there is no hope of success by suture alone, **resection of the injured loop of intestine**, with subsequent **circular suture** of the ends, may be practiced.

10. Even in the Middle Ages, attempts were made to facilitate these operations by uniting the ends of the intestine over cylindrical bodies, which were placed in the interior of the gut, and were afterwards passed with the feces. The „Four Masters" used the dried

trachea of an animal for this purpose; Jobert, a metal ring; Amussat, a wooden cylinder with a groove.

This method has been improved by Neuber, by the use of a decalcified bone tube provided with a groove, and has since then been employed in my clinic several times with excellent results in cases of resection for praeternatural anus.

RESECTION OF THE INTESTINE WITH CIRCULAR SUTURE BY NEUBER'S METHOD.

In a case of gunshot wound of the intestine, this method would be applied as follows: —

1. After the injured loop of intestine has been sufficiently drawn out of the large abdominal wound, and thoroughly cleansed and disinfected with an antiseptic solution, a thick compress of warm bichloride gauze is laid underneath and around the loop of gut, and this is pressed down upon the abdominal wound by the hands of assistants, so as to prevent the protrusion of the intestines, and the entrance of blood or intestinal contents into the abdominal cavity. Then a narrow elastic band is passed through a small opening made in the mesentery, close to the intestine, at a suitable distance from each end of the piece of intestine to be removed, and tied around the gut just tight enough to prevent the passage of feces.

2. The injured loop, together with a wedge-shaped piece of the corresponding mesentery, is then cut away with scissors, beyond the margins of the contusion.

3. After all the divided vessels have been carefully ligatured, the edges of the triangular wound in the mesentery are united by a continuous catgut suture.

4. Then, beginning at the mesenteric border, the edges of the intestine are united (from within) by Wölfler's **internal intestinal suture** (Figs. 636 and 637) until there is only just space enough left to permit Neuber's **bone cylinder** (Fig. 638) to be introduced into the intestine.

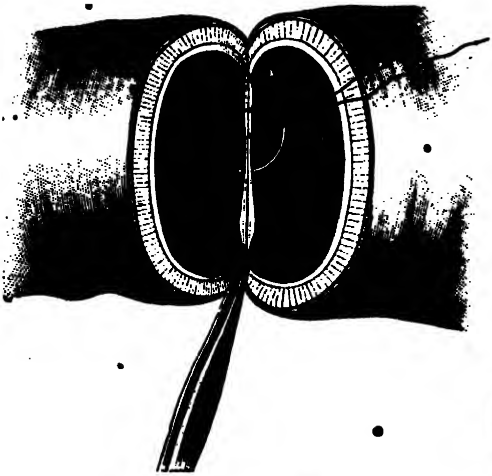
5. The remainder of the edges of the wound are united over the cylinder with Lembert sutures, from without.

6. In order to secure the united intestinal ends firmly upon the bone cylinder, a catgut thread is passed between the wall of the intestine and the united mesentery with a straight round needle, and tied circularly around the gut, so that it gently presses the edges of the wound, and the sutures, into the groove (Figs. 639 and 640).

7. Finally, a few sutures are applied through the peritoneum, so as to secure the folding in of the wound.

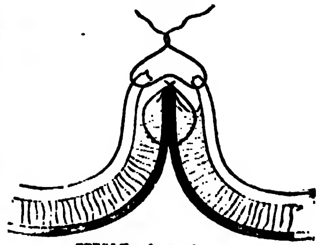
8. Then the two rubber bands are removed, and the sutured loop is returned to the abdominal cavity, after the latter has been very

Fig. 636.



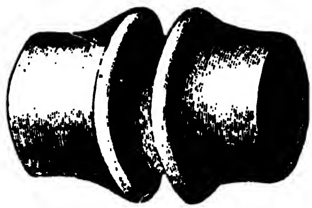
Wölfler's internal suture.

Fig. 637.



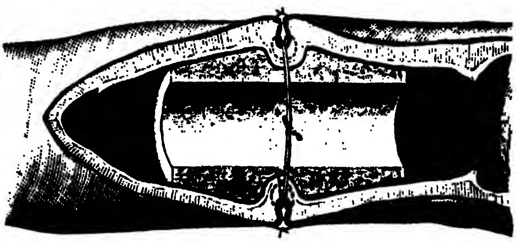
Wölfler's suture.

Fig. 638.



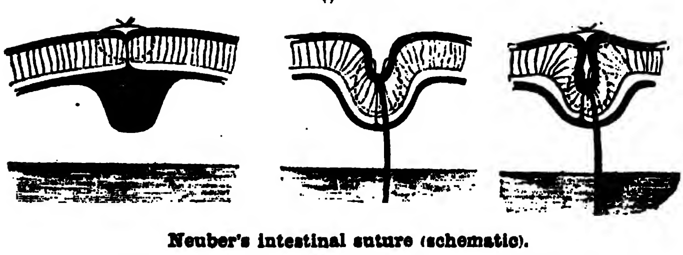
Decalcified bone cylinder.

Fig. 639.



Intestinal suture with bone cylinder (Neuber).

Fig. 640.



Neuber's intestinal suture (schematic).

carefully cleansed in its entire extent with warm salt solution, and then irrigated with bichloride solution, especially if intestinal contents have already escaped into the peritoneal cavity.

9. If it is found that the bullet has wounded the intestine in several places, the same method must be applied to all.[1])

10. If peritonitis is already present, openings must be made in the abdominal wall, in the lumbar region of both sides, and large drainage tubes inserted through them into the cavity, to prevent the collection of septic fluid.

11. Then the large abdominal wound is carefully closed with deep and superficial sutures.

12. The decalcified bone cylinder dissolves entirely, or in part, in the fluids of the intestine, and generally only portions of it appear in the feces.

13. If there is no decalcified bone available, other cylindrical bodies which can be dissolved by the intestinal secretions may be employed for this purpose — for instance, vaginal suppositiories of gelatine, a piece of the largest kind of maccaroni, a piece of a Carlsbad wafer (Weir).

In **gunshot wounds of the rectum,** it is advisable to at once divide the sphincters posteriorly, as far as the apex of the coccyx (sphincterotomy), so that feces will not enter the wound. In order to facilitate the exit of feces, and of the discharge of the wound, a thick rubber tube wrapped in iodoform gauze (Fig. 641) is introduced into the rectum, and is allowed to remain until it is removed by the granulations of the wound. Daily injections are made through the tube with an irrigator, to wash out the rectum.

Fig. 641.

Rectal tube and tampon.

[1]) By performing laparotomy, Bull obtained recovery in the case of a patient whose intestine had been penetrated in seven places by a bullet. The operation was not undertaken until seventeen hours after the injury. See the New York Medical Journal, Feb. 14, 1885.

EXTERNAL URETHROTOMY AND CYSTOTOMY.

1. **Perineal incision of the urethra (boutonnière,** external urethrotomy) is absolutely necessary in **injuries** of the **urethra** (contusion, laceration), and when **infiltration of urine** threatens, or has already occurred.

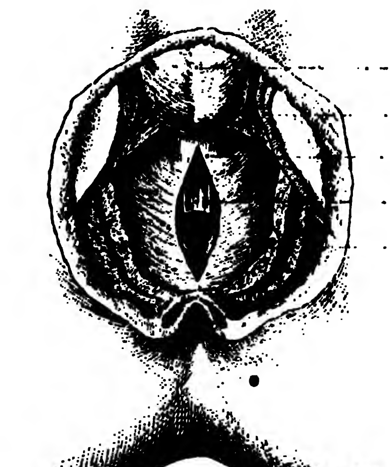
2. A **grooved staff** (such as is used in lithotomy), or a **catheter,** is introduced into the bladder (or, if this is impossible, down to the situation of the injury), and is held exactly in the median line.

3. The patient lies upon his back, with his buttocks at the edge of the table, his legs flexed and abducted (**lithotomy position).**

4. The index finger having been introduced into the anus as a guide, an incision about $1\,^1/_2$ inch long is made exactly in the median line (raphe), between the anus and the scrotum, which is held up by an assistant. The bulb of the urethra, however, must not be wounded, as that would occasion great hemorrhage.

The incision is carried through the deeper parts by cautious strokes of the knife, in the same line, until the groove in the staff is exposed (Fig. 642).

Fig. 642.



5. **If it has been possible to pass the staff into the bladder, an ∼-shaped director is introduced into the bladder along it, and after the staff has been removed an elastic catheter is placed in the bladder, and allowed to remain some (two) days, until the danger of infiltration of urine has passed.**

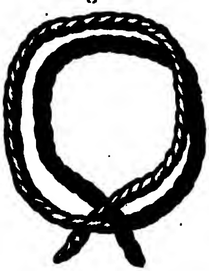
6. But if the previous introduction of the staff fails, because the **rupture** of the **urethra** was complete, the **vesical end of the ruptured urethra** must be found, and this is often a very difficult task.

7. After the coagulated blood has been thoroughly removed from the wound, and the latter irrigated with an antiseptic solution, the edges of the wound are retracted with sharp hooks. Sometimes the vesical end of the urethra can be recognized immediately, appearing as a movable projection of tissue infiltrated with blood, and resembling a firm blood clot.

If it is not discovered at once, the patient is instructed to urinate, or if he is deeply chloroformed, an assistant presses strongly upon the distended bladder.

An attempt is made to seize the edges of the ruptured urethra with toothed forceps or small hooks, where the urine makes its appearance, and to draw them apart.

Fig. 643.



Clove-hitch.

8. If this manoeuvre succeeds, the ∼-shaped director is easily passed into the bladder, and along this as a guide, the elastic catheter. In order to secure the catheter in the bladder, a **clove hitch** (Fig. 643) is made with thick cotton thread, and the end of the catheter passed through it. When the ends of the thread are drawn tight, and knotted once, the knot cannot loosen of its own accord. The ends of the thread are then secured to locks of the hair on the pubis, or to a loose half ring made of a strip of plaster, and fastened just behind the glans penis; or they are sewed to the foreskin.

9. But if the injury to the urethra has been inflicted behind the muscular part, in the prostatic urethra (in gunshot fractures of the pubic bone, for instance), it is generally impossible to find the vesical end of the urethra. But in these cases the danger of urinary infiltration, even into the cellular tissue of the pelvis, is very great, because the deep pelvic fascia has also been injured. In such cases **suprapubic cystotomy** must be performed, and **retrograde catheterization** practiced.

10. If retention of urine follows the injury, and the bladder is distended to the umbilicus, this operation is very easy, for the peritoneum is pushed up by the bladder, and is entirely out of reach of the incision.

11. The abdominal wall is incised above the symphysis, in the median line, until the bladder projects in the wound, the wall of the latter is picked up on each side of the middle line with small hooks, or artery forceps, and is divided between the two, sufficiently to allow a large drainage tube to be introduced into the organ. The edges of

the incision in the bladder can be sewed to those of the wound in the abdominal wall with a few sutures.

12. There is then, generally, no difficulty in passing a bent catheter through the vesical entrance of the urethra towards the penis (retrograde catheterization). A thread or silver wire can be pulled through the bladder on withdrawing this instrument, and with the aid of the thread a rubber drainage tube can be passed out through the perineal wound, so that the urine can escape freely.

13. But if the bladder is empty, this operation is much more difficult, for the reduplication of the peritoneum has sunk below the upper edge of the symphysis. In such cases, after incising the abdominal wall, the dissection must be very carefully carried down until the peritoneal fold is found, and the latter must be drawn up to the upper angle of the wound with a retractor.

14. If a **foreign body** (for instance, a bullet) has penetrated into the **bladder**, it can usually be removed by an incision in the middle line of the perineum (**median cystotomy** of Allarton).

15. **The urethra is incised from the perineum**, as described above, and **the prostatic portion is stretched** by a slow boring motion of the index finger, until a small lithotomy forceps can be introduced, and the bullet extracted with it.

16. If the bullet has already remained in the bladder for some time, so that urinary concretions have formed upon it, it may be necessary to remove it by **suprapubic cystotomy.**

HYPODERMATIC INJECTIONS.

1. The introduction of a solution of morphine into the subcutaneous cellular tissue, is one of the most successful operations, both at the dressing station, and in hospital, and is often the only means of **alleviating** the final sufferings of those who are hopelessly injured.

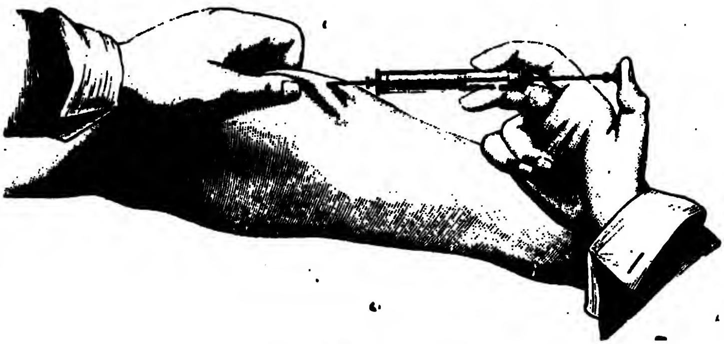
2. An injection of morphine (grain $^1/_6$ to $^1/_3$, for adults) made about 10 minutes **before** the administration of **chloroform** is begun, ensures a quick, quiet, and **lasting anaesthesia.**

3. Every physician should carry a hypodermatic syringe, and a solution of morphine with him, and know exactly what dose of morphine is indicated by each division of his syringe.

4. After the proper quantity of the solution has been drawn into the syringe, any air which has entered is expelled, by pushing the piston forwards while the point of the syringe is held upwards. A fold of skin is lifted on some part of the body (for instance, on the back of the forearm, or on the outer side of the thigh), the needle is quickly thrust through the base of the fold into the cellular tissue,

moved sideways a few times to ascertain that the point has passed through the corium, and has not entered a vein, and the piston is then slowly pushed forwards, emptying the contents of the syringe (Fig. 644).

Fig. 644.



Hypodermatic injection.

5. The needle is withdrawn, and the index finger placed for a few seconds upon the opening in the skin, to prevent the escape of the injected fluid; at the same time, slight pressure, and gentle rubbing with the middle and ring fingers, assists the division and absorption of the solution.

6. Even in this small operation, it is necessary that, not only the syringe, and the operator's fingers, but also the portion of skin chosen for the injection, should be previously carefully cleansed and disinfected. Otherwise, subcutaneous abscesses are liable to follow.

OPERATIONS BY ARTIFICIAL LIGHT.

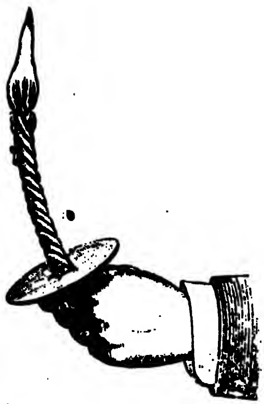
1. The surgeon is often compelled in war to operate by night; and the operations necessary on board ship, during an engagement with the enemy, must usually be performed on the lower decks, by artificial light.

2. An intense light upon the field of operation is absolutely necessary for most operations, and the surgeon must be prepared to help himself by expedients, when, as is the rule, the light is insufficient.

3. A simple, but very good light is the wax taper (Fig. 645), which is made from an ordinary wax taper the size of a quill, by twisting three or four pieces of it into one. To protect the hand from the hot melting wax, the taper is passed through a hole in a piece of pasteboard, or thin wood.

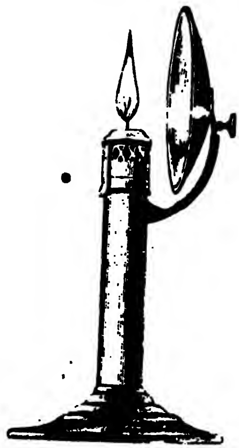
4. An excellent illumination is given by the Ravoth operating candlestick (Fig. 646), a wax candle which is put in a tube with a strong spiral spring. Upon the end of the tube is an adjustable metal reflector, which throws the light upon the field of operation.

Fig. 645.



Wax taper.

Fig. 646.



Ravoth's operating candlestick.

Fig. 647.

Improvised reflector.

5. If this is wanting, an illuminating reflector can be improvised by fastening a silver spoon to a wax candle, by means of a compress and bandage, as is shown in Fig. 647.

ERRATA.

Page 30, line 6, for „mi“, read „my“.
„ 31, „ 4, omit the semicolon after „necessary“.
„ 35, „ 11, from the bottom, for „apear“, read „appear“.
„ 39, „ 18, for „fullfilled“, read „fulfilled“.
„ 40, „ 7, from the bottom, for „moicture“, read „moisture“.
„ 53, Fig. 71, for „sagittall“, read „sagittal“.
„ 54, Figs. 75 and 77 have the titles interchanged.
„ 82, line 4 from the bottom, for „170 ° J.“, read „170 ° F.“.
„ 87, „ 2 „ „ „ , for „wood-sharings“, read „wood-shavings“.

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